Crowdsourcing an emotional wardrobe

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Abstract

Articulating perceptions of a textile digitally is unreliable, so a digital language of feel is desired by researchers, designers and laypeople. Crowdsourcing, or using the wisdom of crowds, has been used successfully to gather insights into people's clothing and emotions. Simply crowdsourcing a language of feel could help people articulate their perceptions of textiles. However, it was ascertained from literature that emotions may help such communication. Subjective and objective measures of emotion may add a richness to a language of feel to make it more effective and engaging. To investigate this, a design research approach was used which involved researching, designing and building a website: wardrobemalfunction.org.uk. This website was used as a tool during an experiment with twenty participants to identify: how and when they currently communicate about clothing, if the website may aid such communication and how they felt about gathering and sharing their physiological data. Interviews from the experiment were analysed using grounded theory and affective framework coding. Data collected from the website was also analysed to see if a common language of feel emerged from the descriptions of participants' clothing. Most participants reported an engagement with, and enjoyment of, the site. They noted that such information would help them communicate about clothing and decide what to buy and what to wear. They also reported that a knowledge of their physiological data could help them with regard to self-awareness, reflection and also empathy with other people. The wardrobemalfunction.org.uk site is not a substitute for physically feeling a textile but offers a useful surrogate experience.
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1 Introduction

1.1 Motivation

Digital economy is fast becoming a part of Britons' lives, using technology to improve living standards. The Digital Sensoria research project, under which this project falls, was created to develop a language to enable communication of sensory perceptions of designs and products through multi-modal digital interfaces. The aim of this project within Digital Sensoria is to help develop such a language to convey perceptions of textiles and create a space for people to share those perceptions.

A lack of digital language of feel is an established problem. Marketing research by Citrin, Stem, Spangenberg, & Clark (2003) has shown that online shoppers' inability to feel products hinders their ability to make purchasing decisions. Further, research by Peck & Wiggins (2006) has shown that communications incorporating touch elements lead to increased emotional response in consumers. They point out that Land's End, a direct marketer, post out fabric swatches to customers in order to let people feel the fabrics. Activities such as posting samples are expensive and time consuming, so an alternative should be sought.

Researchers need a language of feel in order to explore the area thoroughly. There may be other applications of a digital language of feel, including clothing designers wishing to co-design with consumers in order to target users' needs more directly and personally. Additionally, people's reactions to textiles may be useful knowledge for themselves and others.

In his book Emotional Design (Norman, 2004), Norman explains that personalised clothing is feasible, from tailors and seamstresses, but this is outside the budget of most people. He suggests that clothing may be available made-to-order more cheaply and quickly by using personalised design. This is available, for example Nike ID (“Nike Official Store. Nike iD, Make it your own,” nd), but the practice tends to focus on colour and sizing. Perhaps the reason that textile choices are not offered is that communication of textiles (e.g. texture), is currently too difficult or untrustworthy. Norman points out that fashions differ across and within populations largely due to individual differences in cultures and people. Tastes in clothing will vary amongst a population, but
perhaps a common language will emerge to describe the feel of textiles.

Consumers are becoming increasingly empowered via product reviews and social networking, but there is still a need for people to be more involved in the design of clothing in addition to observing and buying. Creating a dialogue between researchers, designers and consumers will help bridge these spaces, enabling all parties to contribute to a deeper understanding of needs and desires. However, it is not clear if and how consumers can articulate their feelings toward their clothing. Tidball & Stappers (2011) suggest that a growth area within the field of crowdsourcing will be inspiration gathering. Crowdsourcing, or seeking the wisdom of crowds, may offer consumer-driven insights to both researchers and designers, and help develop a language of feel.

Linguist and cognitive psychologist Steven Pinker, in his book The Blank Slate (2002), discusses the concept of a language and the way languages develop and evolve. He explains that language can be seen as an internal, individual entity, but also an external entity: “An external language is an abstraction that pools the internal languages of hundreds of millions of people living in different places and times. It could not exist without the internal languages in the minds of real humans conversing with one another, but it cannot be reduced to what any of them knows either.” Investigating how people internalise and externalise their feelings towards clothing is necessary to establish a language of feel.

Some people have an internal emotional connection with their clothing. Stead, Goulev, Evans, & Mamdani (2004) comment that fashion is an emotional discipline and that clothing is a form of social communication. Just as McCarthy, Wright, Wallace, & Dearden (2005) note that jewellery is given an air of intimacy due to its physical connection with the body, the same could be said of clothing which is also worn in physical contact with the body. Picard (1997) stated that emotions play an essential role in communication. Perhaps emotion can help articulate peoples' reactions to textiles.

Research has been done in relation to clothing and wardrobes under the guise of ubiquitous computing. Projects involving sensors in individual wardrobes and items of clothing have been developed, some of which are discussed later in the literature review. Ubiquitous computing is
especially important with regard to wearable sensors. Clothing incorporating biosensors offers the chance to monitor people in different ways, and in a manner which is not overwhelming or inconvenient. However, wearable sensors carry the risk of ethical problems in terms of privacy and autonomy.

As will be explored in the literature review, there seems to be a gap in research to date: emotions have been investigated in terms of clothing and wardrobes ((Shen, Lieberman, & Lam, 2007) and (Cheng & Liu, 2007)). Intelligent wardrobe systems have incorporated crowdsourced information (Tsujita, Tsukada, Kambara, & Siio, 2010). Emotion has been crowdsourced (Kamvar & J Harris, 2011). However, there has been no development of a crowdsourced emotional wardrobe. Perhaps an intersection of affective computing and crowdsourcing will offer a solution to the elusive language of feel.

1.2 Research questions
This project addresses the question: Can a crowdsourced emotional wardrobe support the development of a language of feel?

A design research approach, as proposed by Zimmerman et. al (Zimmerman, Forlizzi, & Evenson, 2007) and discussed further in chapter 3, was used to address this question. In short, this research contributes knowledge which resides in a design artefact: a website which was built as a tool to collect and share data about clothing. An experiment using the website was conducted, where participants wore a biosensor whilst handling garments and were introduced to a mock visualisation of their physiological data. Interviews were analysed using grounded theory and affective coding. The data collected on the website was also analysed to identify trends.

With this research plan in mind, the research question can be broken down into sub-questions:
What will people make of a representation of their physiological data?
How do people feel about crowdsourcing such data?

1.3 Structure of this thesis
Firstly a literature review will explore a range of different topics pertinent to this project. These
include crowdsourcing and the sensing of emotion within the affective computing field. This is followed by a summary of the design research process undertaken to create a tool for use in this project's investigation; the wardrobemalfunction.org.uk* website. Next, qualitative research of the website will be presented, followed by an analysis of results. A discussion of those results will follow, relating to the aforementioned literature review within the context of the research questions. Finally, a conclusion will draw together this report, highlighting the limitations of the investigation and briefly introducing some thoughts for future work.

* The website name, “Wardrobe (mal)Function” was chosen by Digital Sensoria as a way for “thinking about garments people liked (function) and those they didn’t like (malfunction)”: Sharon Baurley of Digital Sensoria
2 Literature Review

2.1 Crowdsourcing
Crowdsourcing assumes that the collective intelligence of a diverse group of individuals will yield a greater intelligence than the sum of individuals within that group. It has been used successfully for problem solving tasks which are difficult for computers to solve but are easily solved by humans. Amazon's Mechanical Turk (“Amazon Mechanical Turk” n.d) is an established and popular crowdsourcing platform. It exploits the skills of human users for tasks which are difficult for computers, such as labelling images.

Tsujita et al. (2010) developed a smart wardrobe system which crowdsourced recommendations for outfits from a user's social network connections. The wardrobe system automatically photographs items of clothing hung on a special hook in the wardrobe prototype. Tags are associated with items of clothing, such as item type (e.g. jacket), appropriate occasions (e.g. work) and suitable weather conditions. The wardrobe system then offers users the opportunity to assemble outfit choices and send these out to the user's social network, so that friends and family may vote for, and offer comments on, the suggested outfits. Results of its evaluation were promising, with a good number of responses after requesting votes and comments. However, the research only evaluated one participant, one of the authors, so further evaluation must be done in order to establish its success.

There are various commercial crowdsourcing clothing sites which offer users the opportunity to create moodboards (“Avenue 7,” n.d), avatars (“GirlSense,” n.d) or upload users' own photos (“StyleMob,” n.d) to receive feedback from the crowd. These sites tend to be aimed at young girls and they do not encourage users to think about texture or emotional reactions to clothing.

Other crowdsourcing research includes Tidball & Stappers (2011) study of a group of designers' reactions to image sets which were sourced either from a crowdsourcing exercise or web image search. The designers preferred the crowdsourced image sets which 'tell a story' and involve 'real people' 'doing things'. This research perhaps suggests that crowdsourced clothing information may be preferred over algorithmic sourcing.
In other related work, Nickerson, Sakamoto, & Yu (2011) have used crowdsourcing in collaborative design to coordinate creative activities across many collaborators. Their research involved novice users to evaluate design ideas, but they propose to use experts who may offer more informed evaluations.

Tomasic et al. (2011) highlight the fact that crowdsourcing is based on the premise that information for the crowd is generated by the crowd, thus requiring a minimum level of activity to be self-perpetuating. They highlight the problem of incentivising use of crowdsourcing sites, noting that Mechanical Turk relies on monetary incentives to attract users to complete tasks. They suggest an alternative incentive; an exchange, whereby users are not allowed access to content until they have provided content themselves. Tidball & Stappers (2011) also discuss some of the reasons that people participate in crowdsourcing activities: interest, task simplicity, peer support and obligation.

Kamvar & Harris (2011) review their popular crowdsourced emotional search engine. The system collects data from public sources such as blogs and social networks where text is present that includes the phrases “I feel” or “I am feeling”. The data is then displayed to users of the search engine via macro-level aggregate data and micro-level data items for browsing. Kamvar & Harris explain the appeal of the system in that it helps people to better understand themselves and others, offering an engaging opportunity for self-reflection and empathy. Their goal was to offer a qualitative and quantitative exploration of other peoples' emotions. They argue that the quantitative analysis of the population supports a cognitive understanding of emotional patterns, while interactions with individual data items support a heightened sense of self awareness and connection with others.

Morris (2011) states that the affective computing and crowdsourcing fields can learn from each other. For example an individual's cognitive reappraisal, where a person re-frames thoughts so as to decrease emotional impact, may be helped by the wisdom of the crowd. Mechanical Turk workers could be recruited to offer help to individuals who seek emotional regulatory assistance.

Tidball & Stappers (2011) propose a set of questions to be addressed when creating a successful
crowdsourcing tool, two of which are relayed here:

- What is the value for the user and contributor?
- How do you motivate participation?

To answer these questions, and as suggested by Morris (2011), affective computing will be examined in the next section to see what the field can contribute to this problem area.

2.2 Affective computing

Affective computing is a multi-faceted field championed by Rosalind Picard (1997), ranging from emotion sensing, recognition, expression and simulation. However, the field is in its infancy and Picard & Daily (2005) discuss the ambiguities in relation to emotion definition, communication and interpretation. Hudlicka (2003) questions the potential roles for affective computing and suggests that it may be used as an interpersonal communication mechanism. She states that emotions serve to communicate intentions and behavioural tendencies between individuals and may therefore help coordinate group behaviour and social interactions.

Emotion could help communicate peoples' perceptions of textile within a language of feel, but emotion itself can be communicated in different forms. Fox (2008) states that problems with emotion self-report include a mistrust of introspection and that emotions are not experienced as discrete units. Picard & Daily (2005) offer alternatives to self report, including physiological measures of emotion. Picard's work is influenced by Damasio (1994), whose research concludes that emotions are not simply cognitive, but are also experienced physically and are in turn influenced by our physiology. He demonstrated the interdependence between emotions and activities previously only considered to require rational thought, such as decision making. An advantage of physiological measures is that they are taken during interactions, rather than after, as is the case with self-report. Also, physiological measures do not rely on a cognitive filter through which emotion is judged. However, each measure of emotion carries a level of uncertainty, thus Picard & Daily (2005) recommend a combination of measures to triangulate results. Morris (2011) concurs: self-report ratings could be combined with data from multi-modal affective sensing technologies. Boehner, Depaula, Dourish, & Sengers (2007) also recommend self-report in combination with physiological measures. They explain that using objective measures to the exclusion of subjective accounts may lead to a too-narrow, often misleading understanding of
emotion. Physiological data alone, they argue, is not enough to understand the subjective experience of emotion, as emotions include layers of sense-making and reflection on top of physiological changes.

Gaver, Beaver, & Benford (2003) originally introduced an argument for ambiguity as a useful device in human computer interaction, especially within affective computing. They explain that ambiguity encourages close personal engagement with systems due to their intriguing and mysterious nature resulting in curiosity. They specifically argue that ambiguity is useful where the source data of a system is itself uncertain. In this case, rather than contriving imprecise physiological data into discrete emotions, thus misleading users, they suggest passing the ambiguity of the data to the users, who will be best placed to fill in the gaps, interpret and appropriate the data themselves.

Building on this, Boehner et al. (2007) propose a new paradigm of interaction design: that affective systems should not be literal in attempts to send and transmit emotions, but instead should support users in understanding and interpreting emotions with their full complexity and ambiguity. They argue that affective systems should avoid attempting to understand human emotions themselves and instead should help users to understand their own emotions and those of others. In relation to communicating emotions, Boehner et al. refer to Picard's assertion that we can never really know how someone else is feeling, only make inferences. They warn that viewing emotions objectively as facts may distort users' understanding. To avoid this, they suggest moving the burden on interpreting from affective systems to users, leaving the system as a conduit.

Similarly, Hook, Stahl, Sundstrom, & Laaksolahti (2008) urge design of affective systems using an "interactional view" to empower users rather than a traditional, prescriptive "informational view" which tends to impose upon users. The informational view describes affective systems which use biosensors to identify users' emotions as discrete information units. This results in a vulnerability for users' privacy and autonomy, in that they have no control over emotion detection and subsequent sharing. Hook et al. argue that emotions are actually communicated subtly and thus require interpretation and sense-making rather than over-simplification. They propose the interactional view which supports users in understanding and experiencing their own emotions, without imposed inference. They suggest an ambiguous approach which is evocative instead of didactic to establish
an interpretive relationship between user and artefact, encouraging close personal engagement.

In line with these ideas, Stead et al. (2004) developed “The Emotional Wardrobe”: clothing which responsively displayed an autonomous representation of the wearer's emotion which was detected via biosensors within the clothing. They explored the idea that the Emotional Wardrobe could be used to aid self-awareness by highlighting emotional states and as self-therapy by adapting behaviour accordingly. Stead et al. purposefully used a more ambiguous model of aesthetic communication, instead of explicit colour/mood associations. This ambiguity resulted in different observers interpreting the aesthetics differently. They conclude that the Emotional Wardrobe expresses the inside on the outside, making the invisible - visible.

2.3 Emotional wardrobes – the story so far

HCI researchers have investigated and developed tools regarding intelligent wardrobes. Here, literature will be examined to see how people think and communicate about their clothing. Also discussed is previous research into intelligent wardrobes which help people organise and recommend clothing.

Rode & Harris (2005) conducted a study of women in regards to their clothing and their wardrobes. They found that women viewed clothing as something greater than utilitarian: a way to express identity. The women tended to dress according to societal norms, (e.g. dressing professionally whilst at work). They also viewed their wardrobes as collective resources, borrowing and lending garments with friends and family. The study noted that wardrobes tended to be rearranged periodically, according to season and weather, holding allegorical historical accounts of individuals and their social relationships.

Rode (2011) built on her previous study by further investigating a more diverse sample of people and their use of wardrobes in order to inform future creation of intelligent wardrobes. This study found that the choice of clothing to wear and the organisation within wardrobes were socially constructed. Participants revealed that their friends' and celebrities' sartorial choices influenced
their own, and women specifically asked the opinions of friends and relatives when selecting outfits. This study also found that when buying new clothing, participants would refer to their wardrobe to inform shopping decisions. Decisions were made by participants about what to wear according to each different occasion in question, along with how the clothing made the individual look and feel. Rode suggests that any technological implementation of a smart wardrobe should enable identity creation, relationship building and reconnecting with memories. Rode also notes that future technologies should be used to complement existing social encounters, such as calling friends for clothing advice, with visual aids.

Shen et al. (2007) built a scenario-oriented recommendation engine to help users select an outfit from a wardrobe. They go some way to incorporate the emotional significance of clothing by allowing users to annotate garments in a wardrobe with descriptions regarding how that garment makes the user feel when wearing it. For example, a user may note: “This jacket makes me feel confident”. Shen et al. mention that outfits may be chosen with the help of a user's friends, but omit detail on how this is done. They also state that the system connects users who share similar tastes, offering an option to browse similar users' wardrobes, but again they omit details.

Cheng & Liu (2007) created a knowledge-based clothing matching system. The system uses neural networks and image processing to automatically catalogue wardrobe contents and recommend outfits according to user requests such as colour and garment type.

2.4 Summary

Various groups of researchers have investigated emotions in terms of clothing and wardrobes. Intelligent wardrobe systems have incorporated crowdsourced information. Emotion has been crowdsourced. However, there has been no crowdsourced emotional wardrobe. The wardrobe research uncovered has focused on an individual's clothing and wardrobe, rather than sentiment and collective feelings about clothing and textiles. Perhaps an intersection of affective computing and crowdsourcing will offer solutions to the problem of communicating the feel of clothing across time and space.
3  Design Research

This research addresses the issue of developing a language of feel through a crowdsourced emotional wardrobe. Specifically, how people react to a representation of their physiological data and also their feelings toward crowdsourcing such data.

To address the research questions, a design research (Zimmerman et al., 2007) approach was used. This involved creating a design artefact; a website, to be used to in research, followed by qualitative analysis of interviews with participants who used the website. Lastly, an analysis of data collected via the website was conducted.

Zimmerman et al. (2007) explain the goals and outcomes of a design research project, stating that design research focuses on contributing knowledge rather than commercially viable products. They argue that a design research project must be framed by a concrete problem, include an articulation of a future preferred state, produce a series of artefacts including prototypes and must result in actionable findings. A key stage in the process should be evaluating the performance and effect of design artefacts in order to discover unexpected effects, connect theory to a problem space, understand the context of use and identify target users. Zimmerman et al. state four criteria for a successful design research project:

- Process – rigorous method and repeatable design process, with rationale for choices made.
- Invention – novel integration of various topics to address a problem. Work must be situated within previous research and demonstrate an advancement to the preferred state.
- Relevance – work must be framed in the real world and provide rationale for the preferred state presented.
- Extensibility – Work must be adequately documented in order for the community to leverage the knowledge.

3.1  Approach

The process of this research will be summarised in this section and further explained in later
chapters. The process is illustrated in figure 1 below as a timeline overview.

![Timeline overview of this project.](image)

**3.1.1 Building the website**

The initial problem was set by the Digital Sensoria research group who sought a language of feel for use in future research. This was followed by a stage of contextual inquiry with clothing designers from industry. The aim was to discover the expert view of textile and clothing nomenclature and communication. This knowledge helped to design a more suitable tool for investigating with the wider public. The website was then designed and built using an iterative process. Usability tests were performed on subsequent prototypes, followed by pilot testing resulting in incremental refinements to the website.

The website technology consists of a front end to collect information and then display it for site users. It also consists of a back end which stores the data from site users in a database and queries back that data for display according to the page requested. See figure 2 below for an illustration of the system architecture.
3.1.2 Experiment using website
An experiment took place involving twenty participants who used the website to submit data about two items of their own clothing. Participants were asked to wear a biosensor in order to trigger discussion of physiological data and inferred emotions during interviews. This will be fully discussed in the Method chapter 5.

Participants interviews were coded using grounded theory, an affective framework and finally a concluding coding pass to combine all codes and categories into themes. The resulting themes will be discussed in the Results chapter 6.

3.1.3 Grounded Theory
Grounded theory data collection and analysis was used on the interviews with clothing designers and experiment participants. Results of grounded theory should fit with the source data (i.e. are representative of participants experiences), and be relevant (i.e. interpret what happened, making relationships between data points visible).

Grounded theory method has been criticised for being time consuming and confusing for novices (Allan, 2003). Grounded theory is usually used for existing real-world behaviours, however part of this project was an experiment to investigate reactions to a novel system, so a modified version of grounded theory was used. Charmaz (2006) advises not to follow traditional inductive grounded theory to the letter, but be flexible in the approach. During the experiment participants did directly
experience the system in question and were questioned about that experience. They were further questioned regarding their existing behaviours to determine if and how such a new system could fit within them. Limited experience of wardrobemalfunction.org.uk website and exposure to biosensors meant that answers was somewhat speculative, but still a good indicator within this study.

The experiment's qualitative research interview script was amended half way through data collection, (after eleven participants), in order to exploit the analysis to that point. This theoretical sampling created a richer data set from the later interviews and allowed reflection. Due to resource constraints, only a modest amount of data was collected and theoretical saturation was not accomplished.

The interview audio recordings were transcribed in their entirety by the researcher, as suggested by Glaser & Strauss (1967). (See Appendix 1 for an example transcript.) The transcriptions were printed and then manually coded using coloured pens. During transcription and throughout the coding process, memos were made on printed copies of transcripts. These informal analytic notes were a useful basis for forming later categories and themes. (See Appendix 2 for example coding sheets.)

Initial, unfocused line-by-line coding was followed by selective coding using an affective framework. Constant comparative method was used; a comparison of data to data, then data to codes. Codes were then refined and regrouped into categories and main themes.

### 3.1.4 Affective coding

Using the affective framework encouraged an analysis of the data via creative, lateral thinking, while framing the analysis round the research questions. McCarthy & Wright (2004) developed an affective framework to design and evaluate technologies as experience in reference to four threads of experience and six sense-making processes. The framework is based on appraisal theory; cognitive evaluation of a situation, conscious decisions made on a level of reaction. The four threads of experience consist of:

- **Compositional** – how parts of an experience fit together
• Sensual – how the look and feel of an experience affects users
• Emotional – which emotions are involved in the experience
• Spatio-temporal – how time and space affect the experience

The six sense making processes consist of:

• Anticipating – expectations before an experience
• Connecting – first reactions of an experience
• Interpreting – making sense of an experience whilst immersed in it
• Reflecting – evaluation of an experience
• Appropriating – relating an experience to one's self
• Recounting – telling others about the experience

3.1.5 Analysing the website data
The website collected and stored multi-modal descriptions of peoples' perceptions of clothing. Like the Kamvar & Harris (2011) emotional search engine, the wardrobemalfunction.org.uk site allows each data item to be browsed on the site for a detailed view of each piece of clothing and the owner's reaction to it. In addition, the site aggregates data, summarising participants' reactions to clothing. This aggregate data was used to see if users communicated in a common language of feel. Specifically it was used to see if there were relationships between different words and pictures they used to describe their clothing.

3.2 Summary
This chapter has introduced the concept of a design research approach which was used in this project to address the research questions. The stages of progression through this project have been summarised. In the following chapter, the research, design and build of the website will be detailed.
4 Design research artefact

To enable the experiment, there was a stage of preparation of materials; the website, physiological visualisations and texture images. The website was used to collect, store and display information about clothing to users of the site. The physiological visualisation was used on the website to convey a simulated impression of users' real-time emotional state. Finally, a set of texture images were displayed to users who were asked to select the image most representative of their clothing.

4.1 Aim

The first aim of this research project was to introduce people to a novel system. No appropriate tool was already available, so a website was built to allow its users first hand experience of the system. That way, subsequent interview data with users would provide useful and grounded insights.

The second aim was to collect data to understand the use of a fuzzy multi-modal language of feel. Peoples' existing communication methods were investigated during interviews to understand current behaviours.

4.2 Academia requirements

Research to inform the design of the website began with a meeting with two Digital Sensoria academics. They wanted to understand what people desire from their clothing, but noted that a language of feel to facilitate investigation of the topic was lacking. They needed insights into perception of textiles and were intrigued to know if emotional connotations could aid communication regarding clothing. It was decided to record participants physiological changes whilst handling textiles and then display that data to participants to discover if this may help communicate a language of feel. A real-time visualisation of users physiological changes had to be simulated, as no real time connection from a biosensor to computer was available.

4.3 Contextual Inquiry

To inform the design of the website and ensure a suitable tool was built, two clothing designers
were interviewed. The designers, one male (32) and one female (28), were interviewed in their respective offices to discuss their current communications regarding clothing and textiles. Interviews lasted approximately 40 minutes each and were recorded using an Olympus VN-8500PC digital voice recorder. Photos were taken of artefacts, (using a Canon Digital Ixus 860 IS camera ), such as textile swatches, a mood board wall, inspiration digital photos, photo filing systems on the computer and “tech pack” sheets which are used to communicate with production factories about textiles, (see Appendix 3 for example photos).

4.4 Results
The interviews with designers were transcribed and analysed using grounded theory line-by-line open coding (see Appendix 4 for example transcription). Four main themes emerged:

4.4.1 Theme 1 - Colour
One designer noted that colour is an important factor when storing and retrieving mood board images which are used for inspiration:

P1: “[Clicking through his inspiration images] These aren't categorised, these are stored by date, so I just look at the colour of it... iPhoto is much more visual so its easier to use, a lot easier to work with. ”

The other designer pointed out that Pantone colour references (a standardised colour reproduction system) are an essential part of communicating with fabric suppliers and end consumers:

P2: “With [a particular factory] I always use the Pantones. For fabrics, the colours always have Pantone names already. I use those names. “

4.4.2 Theme 2 - Texture
Designers emphasised the importance of texture when designing clothes:

P2: “[Handling a particular fabric] Its a hard hand feel and it wouldn't be comfy to wear. One of our things is that the fabrics have to be really soft, like your favourite t-shirt that you have washed over and over again. The vintage vibe.”
Note the use of texture descriptors “hard” and “soft”, both common and non-technical words. This could indicate that a non-technical taxonomy of texture words may be adequate to describe textiles. However, the designer then uses a longer description to fully articulate the hand feel she desires.

Both designers stated that physically handling fabrics was essential to their design process and any other method of detecting or expressing texture is inferior:

**P1:** “Depending on where I am, I sometimes have to take a photograph but usually its always better to have something you can feel, so I would try to take a cutting if you can.”

**P2:** “I have to feel it because sometimes its different if you have got it in your hand.”

However, communicating texture to others is a necessary but difficult task to get right:

**P1:** “It's hard to describe all these things, so a book would be useful for how to talk about fabric. I've never seen a book that goes into detail of hand feel of textiles.”

Participant 1 admits here that despite his expert knowledge, he is lacking in knowledge to adequately articulate tactile perceptions. This reveals a need, even for clothing designers who handle textiles regularly, to establish a common language of feel.

### 4.4.3 Theme 3 - Imagery

Mood boards including many images are created by both designers to inspire their design process:

**P1:** “I look at blogs and store photographs of things I like. Its patterns and things that inspire me.”

**P2:** “I do lots of research by looking at Getty and Rex, the photo libraries, for t-shirt inspiration of the actual prints... I'll be constantly collecting images.”

As well as individual inspiration, such images are also shared within design teams:

**Researcher:** “How do you share between the three designers on the team?”

**P2:** “Everyone has done their own research and then we go through the research together and then print off the aspects that we all feel fit. So everyone has their own folders. The main themes we print out.”

Designers resort to printing digital images to share and articulate their inspiration sources.
Images are also used to communicate back and forth between designers and fabric suppliers:

**P2:** “I'll send the factory an email with images... I really wanted a shiny print so I sent them this [points] so it looked like tar. I send all sorts of mood board type things... This one you could describe it like tie dye because I sent them lots of tie dye pictures. ”

**P2:** “ I've found [suppliers] really like images. Say for the distressing we are trying out, I was sending pictures to them... For development I sent them just swatches but for sampling, I put pictures in the tech packs so they can refer to it as well. The more information you can give them, the easier it is. “

One designer noted that a selection of images is always preferred:

**P1:** “ *It's never enough to have one picture, because of the quality of light when they shot it, its not good enough.* ”

Images are used by designers as sources of inspiration and to communicate with others which is perhaps proof that a “picture is worth a thousand words”.

### 4.4.4 Theme 4 - Communication

Communicating with fabric suppliers offers many challenges to designers. They must communicate with different factories who each have their own nomenclature, and overcome language barriers to reach their goal of remotely sourcing exactly the fabrics they desire.

There is no universal and systematic way of communicating about fabrics:

**P2:** “*Each factory calls it different things as well. I think its the language barrier, once you get a certain factory, you use a certain terminology that they use and you know what they mean by it. I always said 'soft hand feel water based print'. I just want it to have a really soft hand feel when you feel the print. Then I changed factories and now they did a water based print totally different to how I'm used to. So you get used to the terminology... They say what you are referring to is a discharge print, so its good to work out your terminology beforehand.*”

It was also discovered that designers rarely communicate with the end consumer, certainly not taking a user-centred approach:

**P2:** “*Only via the website would we ever have contact with customers. They send us images of*”
people wearing t-shirts saying 'Oh can you make this one for us'.

A system such as wardrobemalfunction.org.uk provides an opportunity for designers to learn about their end consumer.

These results indicate that designers communicate with a very sensual language, both visual and tactile, but this is not efficient when communicating digitally. They resort to printing digital images and posting textile swatches which is slow and expensive. There is scope for them to communicate within design teams, with suppliers and with end consumers.

### 4.5 Industry requirements

The analysis of research with designers informed the design of the wardrobemalfunction.org.uk website which included a greater emphasis on imagery over text. Images can be understood across language barriers, although interpreted differently depending on culture.

A colour question was added to the website as designers stressed the importance of colour when browsing for or scanning through a collection of images. The designers also consistently referred to colours as Pantone (“Pantone,” n.d) references, an international standardised colour reproduction system. In light of this, the colours in the browse section of the website were designed to mimic the style of Pantone references.

Additional design decisions were informed by the photos from the sessions with designers. Firstly the number of photos of each textile allowed to be uploaded to the site were increased from two to five, as the designers tended to represent each idea with more than two images.

### 4.6 Website back end design

The website back end was built using the PostgreSQL database management system (“PostgreSQL,” n.d). (See Appendix figure 5 for the entity relationship diagram showing the architecture of the database.) This database stored and retrieved the data added by users of the
wardrobemalfunction.org.uk site. The database was queried using SQLAlchemy ("SQLAlchemy," n d), a Python toolkit. The web requests are handled using Flask ("Flask (A Python Microframework),” n d), a Python web application framework.

4.7 Website front end design

The wardrobemalfunction.org.uk site was designed starting with sketched ideas, through low fidelity wireframes, high fidelity wireframes and finally the HTML5 prototype website as used in the experiment. (See Appendix 6 for example illustrations of each stage in design).

Figure 3 below is a screenshot of the webpage which allows users to add textiles or garments to the collective wardrobe. Once added, the garment may be viewed in the 'Browse' section of the site and is included in the aggregate data in the 'Analysis' section of the site.
The 'Add' section of the site allows users to enter information regarding textiles and garments to the wardrobe. Question 1 asks how a garment makes the user feel. The list choices are based on a taxonomy to help users articulate which emotion they felt. The taxonomy was sourced from Hertenstein, Keltner, App, Bulleit, & Jaskolka (2006) research regarding emotions associated with touch. Question 2 regards the texture of a garment. The list choices of forty bi-polar texture word pairs were sourced from a literature review by a Digital Sensoria researcher regarding textile handling literature (Atkinson, 2011). Question 6 asks for the fibre content breakdown on the textile. More than one fibre may be added per textile. Table 1 below shows a summary of the questions from the 'Add' page of the site.
Table 1. Summary of the questions from the 'Add' page of the website.

<table>
<thead>
<tr>
<th>Question number</th>
<th>Question</th>
<th>Question type</th>
<th>Form validation</th>
<th>Possible choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How does it make you feel?</td>
<td>Drop down list</td>
<td>Only one may be selected</td>
<td>Amused, angry, bored, contemptuous, disgusted, fearful, happy, joyous, interested, proud, sad, shameful, surprised</td>
</tr>
<tr>
<td>2</td>
<td>How does it feel to touch?</td>
<td>Drop down list</td>
<td>Only one may be selected</td>
<td>Clingy, coarse, cool, crisp, crumpling, dry, elastic, fine, flat, flexible, flowing, grainy, greasy, hard, harsh, heavy, light, limp, matte, non-stretchy, organic, relief, resilience, rigid, rough, shiny, sleek, slippery, smooth, snagging, soft, solid, spongy, stiff, supple, synthetic, thick, thin, warm</td>
</tr>
<tr>
<td>3</td>
<td>Which image best represents the fabric?</td>
<td>Select one image from a set of 40 displayed in a dialog</td>
<td>Only one may be selected</td>
<td>One of forty, For example:</td>
</tr>
<tr>
<td>4</td>
<td>Upload images of your fabrics</td>
<td>File uploader</td>
<td>Up to 5 images allowed</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>Colour(s)</td>
<td>Text field</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>Fibre content</td>
<td>Drop down lists with percentage field per fibre</td>
<td>May add more than one fibre, no limit. Must include a percentage (integer &gt; 0 and &lt; 101) for each fibre.</td>
<td>Cotton, polyester, elastane, lycra, rayon, wool, silk, bamboo, polyamide, nylon, acrylic, viscose, cashmere</td>
</tr>
<tr>
<td>7</td>
<td>Notes</td>
<td>Text field</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**4.8 Physiological visualisation**

A simulated visualisation of each user's emotional state was displayed to participants. This was described to them as being extrapolated from their real-time physiological data captured from a worn biosensor. This visualisation had to be simulated as the biosensor used during the experiment did not have a wireless data connection.

The visualisation of physiological data was intentionally abstract, with only a few variable parameters. Gaver et al. (2003) suggest that ambiguous representations allows designers to go beyond the current limits of technology: “Ambiguity provides a context that allows the use of
inaccurate sensors, inexact mappings and low-resolution displays because it encourages people to supplement them with their own interpretations and beliefs”. Ambiguous visualisation was also used to create a sense of anonymity in the physiological data and to not allow direct connection to any individual.

The physiological visualisation was created using HTML5 and CSS3 animation techniques using a rotating image which changed colour, speed of rotation and shape according to questions answered by each user. The animations were influenced by work from (K. Hook et al., 2008), (Isbister, K Hook, Laaksolahti, & Sharp, 2007) and (Kamvar & J Harris, 2011) and were purposefully designed to only suggest a sense of emotion which is open to multiple interpretations, rather than be a direct representation of inferred emotion.

The shape of the animation began as a simple spiral, but during pilot testing, participants incorrectly assumed it was a 'page loading' animation. The various shapes of the animation, (see table 2 below for table of shapes and associated textures), used in the experiment were supplied by a Digital Sensoria researcher and were related to texture words.
Table 2. Shapes and associated textures, as used in the physiological visualisation animation on the website.

The changing colour of the animation was based on the e-moto project (Fagerberg, Stahl, & Hook, 2004) which was in turn based on the colour theory work of Itten (1974). The colour relationships to emotions were estimated, but this was not considered critical because the visualisation is purposely fuzzy. The speed of the animation also changed according to choice of emotion, with
emotions of high arousal being faster than those of low arousal. The arousal level was based on Russell's Circumplex Model of Affect (Russell, 1980).

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Colour</th>
<th>Animation Speed (in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happy</td>
<td>Orange red</td>
<td>4</td>
</tr>
<tr>
<td>Bored</td>
<td>Midnight blue</td>
<td>15</td>
</tr>
<tr>
<td>Amused</td>
<td>Light orange</td>
<td>6</td>
</tr>
<tr>
<td>Angry</td>
<td>Sea green</td>
<td>2</td>
</tr>
<tr>
<td>Sad</td>
<td>Dark blue</td>
<td>9</td>
</tr>
<tr>
<td>Disgusted</td>
<td>Teal</td>
<td>4</td>
</tr>
<tr>
<td>Fearful</td>
<td>Lime</td>
<td>7</td>
</tr>
<tr>
<td>Joyous</td>
<td>Orange red</td>
<td>3</td>
</tr>
<tr>
<td>Shameful</td>
<td>Dark green</td>
<td>6</td>
</tr>
<tr>
<td>Proud</td>
<td>Light blue</td>
<td>8</td>
</tr>
<tr>
<td>Contemptuous</td>
<td>Forest green</td>
<td>10</td>
</tr>
<tr>
<td>Surprised</td>
<td>Yellow</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 3. Colours and speeds of the physiological visualisation animation on the website. Animation speed is the time it takes to make one 360° rotation.

### 4.9 Evaluation of initial design

Two informal usability tests were performed to evaluate the developing website prototype. These were performed in a cafe using a laptop and participants were requested to think aloud as they used the website to enter information about a t-shirt into the site. Example changes included an increase in font size and a decrease in size of stakeholder logo images in the footer.

The qualitative research experiment was run as a pilot with four participants on two separate days, from the UCL HCI-E MSc course, 1 male and 3 females. Participants used the website as planned for the experiment, with the addition of a few questions regarding the use of the website. Notes from observing the behaviour of participants were also made, which included repeated mistakes across participants and questions asked which could have been better explained by an improved design. An analysis of pilot test recordings and memos was used to refine the website design. Changes to the site included a re-ordering of questions to create a more coherent flow, numbering of questions to guide participants to answer them all and a reduction in the number of texture images.
4.10 Refinement of texture image set

A collection of texture images were supplied by students at University of the Arts, London (Central St Martins and London College of Fashion). A total of 266 images were supplied (see Appendix 7 for examples) for the texture terms, “cool”, “flexible”, “rough”, “smooth”, “stiff”, “thick”, “thin” and “warm”. There was a disproportionate number of images within each texture category due to a reported difficulty in representing certain terms (e.g. flexible) in static images, which may have lead to a disproportionate weighting of data within the more popular categories. 266 images seemed to be too large a number to expect website users to choose from, a theory confirmed by negative comments during the pilot test. To whittle down the total number of images to a more manageable 40, an online questionnaire was used to determine which five images best represented each term within each category. See example section below, figure 4.

![Screenshot of a section of the questionnaire used to narrow down the texture image set.](image)

Figure 4. Screenshot of a section of the questionnaire used to narrow down the texture image set. This image shows the question regarding 'rough' texture images.

The questionnaire was published on Facebook and Twitter and was free to be completed by any native English speakers. A total of 31 participants completed the entire questionnaire and the results were analysed to find the five most popular images per texture term, (see table 4 below). These 40 images were then used on the wardrobemalfunction.org.uk website.
<table>
<thead>
<tr>
<th>Image</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>71.0%</td>
<td>22</td>
</tr>
<tr>
<td>8</td>
<td>64.5%</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>71.0%</td>
<td>22</td>
</tr>
<tr>
<td>12</td>
<td>64.5%</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td>74.2%</td>
<td>23</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>21.4</td>
</tr>
<tr>
<td>Standard deviation</td>
<td></td>
<td>1.34</td>
</tr>
<tr>
<td>6</td>
<td>74.2%</td>
<td>23</td>
</tr>
<tr>
<td>11</td>
<td>35.5%</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>35.5%</td>
<td>11</td>
</tr>
<tr>
<td>29</td>
<td>54.8%</td>
<td>17</td>
</tr>
<tr>
<td>35</td>
<td>32.3%</td>
<td>10</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>14.4</td>
</tr>
<tr>
<td>Standard deviation</td>
<td></td>
<td>5.55</td>
</tr>
<tr>
<td>3</td>
<td>61.3%</td>
<td>19</td>
</tr>
<tr>
<td>7</td>
<td>58.1%</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>35.5%</td>
<td>11</td>
</tr>
<tr>
<td>24</td>
<td>48.4%</td>
<td>15</td>
</tr>
<tr>
<td>37</td>
<td>35.5%</td>
<td>11</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>14.8</td>
</tr>
<tr>
<td>Standard deviation</td>
<td></td>
<td>3.77</td>
</tr>
<tr>
<td>2</td>
<td>64.5%</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td>51.6%</td>
<td>16</td>
</tr>
<tr>
<td>17</td>
<td>32.3%</td>
<td>10</td>
</tr>
<tr>
<td>22</td>
<td>61.3%</td>
<td>19</td>
</tr>
<tr>
<td>34</td>
<td>38.7%</td>
<td>12</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>15.4</td>
</tr>
<tr>
<td>Standard deviation</td>
<td></td>
<td>4.34</td>
</tr>
<tr>
<td>5</td>
<td>29.0%</td>
<td>9</td>
</tr>
<tr>
<td>11</td>
<td>51.6%</td>
<td>16</td>
</tr>
<tr>
<td>13</td>
<td>48.4%</td>
<td>15</td>
</tr>
<tr>
<td>18</td>
<td>32.3%</td>
<td>10</td>
</tr>
<tr>
<td>36</td>
<td>58.1%</td>
<td>18</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>13.6</td>
</tr>
<tr>
<td>Standard deviation</td>
<td></td>
<td>3.91</td>
</tr>
</tbody>
</table>

Table 4. Summary of results from questionnaire used to narrow down the texture image set. The image columns detail the image ID number as used within the questionnaire.
Table 4 above details the results from the texture image questionnaire. It shows that there was most agreement regarding the 'thin' image category, and least agreement regarding the 'rough' category.

### 4.11 Summary

This chapter has detailed the process of research, design, build and refinement of the wardrobemalfunction.org.uk website. The website was then used as a tool to explore if such a system may be useful to people when describing the feel of their clothing. This experiment will be described in the following chapter.
5 Method

5.1 Aim
An experiment was performed to investigate the reactions of participants regarding the information requested and displayed on the wardrobemalfuction.org.uk. The investigation also explored how participants reacted to a visualisation of their own physiological data and how they felt about publicly sharing such information.

5.2 Participants
Twenty participants were recruited from the UCL Psychology Pool with an incentive of a £20 Amazon gift voucher. Ages of participants ranged from 20 years to 51 years, (mean age 28.45 years, stdev 8.33), split between 11 females and 9 males. Participants were tested individually in quiet rooms on the UCL campus. Participants were requested to bring along “two casual tops” to the experiment session. To investigate a language of feel, a homogeneous sample of clothing was desired. Casual tops should be homogenous, as opposed to, for example, a “favourite item of clothing” (i.e. wedding dresses to shoes to hats). Also, there was a fear that embarrassing garments may be brought in by participants.

Participants were screened to be native English speakers so as to mitigate cultural differences and to ensure participants could easily choose words from the website to accurately represent their reactions to textiles.

5.3 Materials and apparatus
A demographic questionnaire printed on paper was used to record age and sex of participants. This was completed by each participant at the beginning of each session along with an ethics consent form. (See Appendix 8 for a copy of the questionnaire and consent form). Each participant was introduced to the experiment by hearing a brief read aloud from a printed sheet. This was to ensure that each participant heard the same instructions and no element was forgotten, (see Appendix 9 for a copy of the brief). Also, an experiment checklist was used to ensure consistency and to record additional observations for each participant, including times during which participants felt the
textiles and clicked the biosensor. (See Appendix 10 for example completed checklists).

The Affectiva wrist-mounted Q Sensor biosensor (“Galvanic Skin Response for Measuring Emotions | Q Sensor | Affectiva,” n.d) was used during the experiment to record GSR and temperature of each participant. This sensor was not as accurate as finger or palm mounted sensors but was sufficient for this qualitative research. It simply gave participants the general experience of having their physiological data gathered. The wrist mounting of the sensor also allowed free use of hands when feeling textiles during the experiment.

The website was accessed using a Toshiba R700 laptop running Windows 7 with a separate Bluetooth mouse, using the Chrome web browser version 12.0.742.122. Photographs were taken using a Canon Digital IXUS 860 IS camera and interviews were audio recorded using an Olympus VN-8500PC digital voice recorder. A grey, 100% cotton UCLIC branded control t-shirt was used for each test session with participants.

An interview question guide was used during interviews with participants. A few initial ice-breaker questions were asked to create a rapport between experimenter and participants, followed by open ended questions.

5.4 Procedure
Participants were first asked to complete a short demographic questionnaire on paper. The biosensor was fitted to each participant's non-dominant wrist so as to acclimatise. Participants then ran through an experiment with another UCL HCI-E MSc student regarding interactive touchscreen animations of fabrics with sound representations. The other project did not interfere with this research but did start participants thinking about and touching fabrics.

Participants were then briefed on the experiment detailed in this report. Particularly, they were made aware of the measures the biosensor was recording and that a simple visualisation of those measures would be shown to them on the right hand side of website, to be discussed in the interview. All participants agreed to continue, so a test textile was used to run through the experiment procedure.
and ensure the participants were familiar with the experimental procedure and the website.

The experiment procedure consisted of one minute rest time during which a baseline from the biosensor was demarcated by clicking it. Participants were then asked to feel the textile for one minute and think about how the textile felt to touch, how it made them feel and how it compared to other textiles (see figure 5). The verbal instructions were only given during the test section of the experiment; during the experiment proper the experimenter was quiet. After the one minute feel time, the participants were informed that their physiological data would be uploaded to the website. In reality, each participant number was recorded in the Notes field on the site which gave the experimenter time with the laptop to give the impression of uploading the physiological data. Then participants were asked to answer all questions on the website. Participants sometimes asked questions about the website such as, “Am I only allowed to pick one word from this list?” and “I'm not sure what the fibre content is?”, which the experimenter would answer. No questions were asked during the experiment proper.

Figure 5. Participant handles the test t-shirt for 1 minute whilst wearing the wrist mounted biosensor.

After the test textile, participants were requested to take digital photos of the garments they bought with them. The photographs were then loaded onto the computer desktop and named with the participant's number and garment ID (e.g. P2A, P2B).

During the experiment proper, participants were reminded to click the biosensor wrist band before and after feeling their garment for one minute. Participants were then asked to enter the data about
their own garment into the website, (see figure 6) and repeat the experiment using their second garment.

![Figure 6. Participant enters data about the test t-shirt into the website.](image)

After using the website, participants took part in a semi-structured interview. Interviews were audio-recorded and lasted between 10 and 20 minutes each (see figure 7 below). A script was followed (see Appendix 11 for interview questions), but questions were tailored to each participant, mirroring their language and following any intriguing paths in the conversation as judged subjectively by the researcher. Questions included critical incident, users' past experiences and speculative uses of the website. These varied lines of questioning were used to encourage participants to consider the website from different perspectives. After interviews the participants were de-briefed.
After 11 participants completed the experiment, sessions were paused for a few days. During the break, the experiment was amended slightly. The interview script was expanded to include a section of “think aloud” with each participant. During the think aloud, each participant was asked to talk through his/her exploration of the items added to the site by other participants. This was to ascertain participants' immediate reactions to the browse section of the site and to encourage an articulation at the 'connecting' and 'reflecting' stages of sense-making.

5.5 Summary

This chapter has detailed the experiment which was conducted to explore the use of wardrobemalfunction.org.uk website as a tool for people to describe the feel of their clothing. The following three chapters will explore the results obtained during this experiment. Various methods of analysis have been employed: grounded theory and affective framework coding, data analysis of information collected on the wardrobemalfunction.org.uk website and a brief overview of physiological data from biosensors worn by participants.
6 Results 1 – qualitative research

This chapter will summarise the four main themes which emerged from analysis of interview data: both grounded theory and affective framework coding. Participants will be referred to as P1-P20 for anonymity. Example quotes are included here for each theme with supplementary evidence in the Appendix, figure 12.

6.1 Initial observations

Some participants were not interested in a website such as wardrobemalfunction.org.uk. Six participants articulated they were not interested in clothing and so could not see a use for the website in their lives (see summary table Appendix 13). Some lack of interest was expected as participants were not pre-screened for an interest in clothing. In light of this, the wardrobemalfunction.org.uk website should not target the everyman, instead focusing on those who may engage with, and benefit from, the site. Those who are not interested in clothing are also probably not suited to articulating properties of clothing and thus contributing to the language of feel. However, the disinterested participants' apathy towards the site gave valuable insights into why they did not engage with the site.

6.2 Themes

6.2.1 Theme 1 – Language of feel

As well as traditional forms of communication such as talking, more abstract and contemporary forms of communication were also identified. These included social self expression via clothing, communication regarding clothing via social networks and interpretive communication via ambiguous imagery.

Some participants mentioned using clothing to express their emotions, for example:

P17: “You identify what you wear with your emotions... You project [your emotions] on to the way you behave, the way you talk, the way you dress”

This concurs with Picard's assertion that emotions play an essential role in communication.
Other participants referred to communication regarding clothing on social networks, for example:

**P9**: “Yesterday was my first Facebook status about, um, shoes”

(See also Appendix 12, reference 1)

Many participants stated that the ambiguous imagery used on the site was intriguing and appealing. Participants were particularly interested in interpreting the imagery and using that information as a novel form of communication:

**P19**: “It’s a weird way to engage with people about things, where you figure out a little bit of what's going on in their head”.

(See also Appendix 12, reference 2)

Most participants engaged with the ambiguous relationships between garments and chosen texture images, for example:

**P17** discussed her interpretations of another participant's texture image choice: “Since these belong to people, it made me work out the kind of people that wear that... This person probably thinks this dress is really out there, that it is really cool because she chose the ice cubes.”

**P18** gave his thoughts on another participant's texture image choice: “I'm looking to see why it says rough... [Points to the texture image] If that shirt feels like that on your skin, I would not wear that shirt”

(See also Appendix 12, reference 3)

These examples demonstrate that the words and images chosen by participants complement each other and together give a richer description of the garment in question.

Of the twenty participants, eight mentioned they would have preferred to see their physiological data in a more scientific form.

**P9** when questioned about a preferred form of the physiological data: “Maybe a graph, so you know exactly what information is being shown”.
Participants mentioned that meaningful interpretation of physiological data is key to its usefulness:

P9: “Physiological by itself is just a number really”

P14: “Is this the biosensor data of that person? I'd like to see more. A graph possibly, of how the person reacted to the material”

P14 summed up sentiment regarding the visualisation: “With an image, it depends on how you interpret it”

These sentiments are in contrast to the theory by Gaver et al. (2003) that ambiguous representations are best suited for ambiguous data. It remains to be seen that, if presented with a graph of physiological data, laypeople could interpret that data any better than an abstract visualisation.

Participants reported a curiosity about the physiological data visualisation and the texture image choices of other participants.

P13: “Its quite abstract and unusual, so out of curiosity I would probably click on it”

This curiosity may be an emotion that the wardroblemalfunction.org.uk site could exploit to attract users and hold their interest. (See also Appendix 12, reference 5)

One participant likened the physiological data visualisation to a mood ring, a simple piece of jewellery which changes colour according to the body temperature of the wearer, publicly displaying an indication of mood:

P12: “Its sort of like a mood ring. One of those things you bought in a toy store.”

Some participants pointed out that digital representations of garments was no substitute for the real thing. However, if directly experiencing garments was not possible for any reason, the website was a useful communication tool:

P14: “I find nothing beats touching the materials... [The website] would be helpful if I'm in a situation that I cannot buy a material personally and seeing these descriptions and seeing these images would be helpful.”

P19 explained when the website would be useful: “If you were trying to get a sense of what something would be like without actually having it there”
Again, these comments are encouraging as they lend support to the idea of the website as a useful tool which would appeal to users.

6.2.2 Theme 2 - Using physiological data

Most participants (95%) expressed an interest in seeing their own physiological data, (see key points spreadsheet for breakdown, Appendix 13). They were interested in seeing their physiological data regardless of their interest in clothing, suggesting that this may be a good incentive to draw people to using the site. Many participants expressed reasons for their interest in physiological data aside from its relation to clothing and textiles.

65% of participants were interested in comparing their own physiological data over time or across different experiences. For example, P1 wanted to:

P1: “See if it goes up or down depending on what I'm doing”

Participants were eager to see their physiological data as a means to correlate their subjective interpretation of how they feel to the way an objective biosensor interprets how they feel.

P14: “Whether the biosensor is telling me the same thing as my mind is telling me”

(See also Appendix 12, reference 6)

This curiosity in physiological data ranged from a broad interest:

P11: “I do have a fetish for sneakers. If I saw my reaction to sneakers that might be interesting to know”

To specific evaluations of one's own emotions:

P6: “You could self-analyse”

P10: “If I wasn't my normal self I would like to see how it varies from the norm”

As well as analysing their own data, participants were also keen to compare their data with that of other people:

P5: “How all the different values change according to what fabrics they are feeling... I would assume my information would be slightly different from other people's”

P11: “I would like to compare the way they had a marked difference in their data and see what items of clothing prompted it, to see if it matches up with my tastes, to see if it also
prompts the same type of responses in me... Just to see how normal or abnormal my responses would be”

This wish to compare physiological data with that of other people highlights that participants view their data in a social space, for sharing and exchanging information. (See also Appendix 12, reference 7)

Some participants expressed a wish to use knowledge about their emotions and modify their behaviour accordingly:

P19: “Dressing to influence one's mood”

Again, this proposed aspect of the site could attract users as well as offer an added dimension to the language of feel developed from the site. (See also Appendix 12, reference 8)

6.2.3 Theme 3 – Decision making

During discussions of the utility of the information on the wardrobemalfunction.org.uk website, participants were broadly split into two roles; “contributors” who would actively add garments to the collective wardrobe and “consumers” who would passively use the information on the website. Some participants expressed an interest in both contributing content for the site and consuming content from the site as keen clothing enthusiasts. Motivations for using the site primarily fell into two categories: deciding what to buy and deciding what to wear.

Participants repeatedly mentioned that the information on the website would aid shopping:

P20 when asked if the site would be useful for her: “Yeah maybe for internet shopping. If a lot of people like that material then it would be good to have some scientific information to back it up.”

(See also Appendix 12, reference 9)

Participants also frequently related the information on the wardrobemalfunction.org.uk website with deciding what to wear. Weddings were the most frequently mentioned significant event for which people desire opinions from others regarding what to wear.
"A few months back, one of my friends got married, so if something like this could have been there she could have uploaded all of the pictures of dresses she was considering for her marriage... and not only five or six friends commented, but hundreds of them"

P6 referred to wearing a Scottish kilt at events: “It would be fantastic to know before I went to a wedding or ball what everyone else liked because sometimes, one can get slightly self-conscious being the only guy in a skirt”

This desire for a way to quickly ascertain the opinions regarding choice of outfit may prove to be a valuable incentive for users to participate in the crowdsourced wardrobe.

6.2.4 Theme 4 - Ethics
Under the umbrella term of ethics, a few topics arose from the interview data including privacy, ownership of data and discussions on a wearable biosensor.

Many participants believed anonymity to be a key factor in their acceptance of a physiological crowdsourcing website:

P11: “If it were not anonymous I would have reservations, but I don't think that the content of the information is too sensitive, so I may still go ahead with it”

P18: “Its fine [to share the data online] if you can't identify me”

This suggests that site contributors should remain anonymous. (See also Appendix 12, reference 10)

One participant pointed out that anonymity was essential, but was still tentative in her endorsement of such crowd sourcing:

P19: “If there was no way to know exactly who it is, I think I wouldn't have an issue.”

Researcher: “What if people could identify you?”

P19: “I think that would be a little, [pause]. It would depend who has access to it.”

In contrast to this, some participants expressed an interest in specific groups of peoples' physiological data. Of particular interest was physiological data of acquaintances, for example:

P6: “It would be interesting to see friends, but it would be more useful, for instance your colleague or your boss”

One participant viewed physiological data of his friends as way to get to know his friends on a
deeper level:

P6: “You want to know what your friends are, people you do know well, what they are like just beyond the surface”

It seems that participants did not want to expose their identities in relation to physiological data, but did wish to see the identities of other people in relation to physiological data. This apparent conflict could be resolved by allowing users to selectively share their information from the collective wardrobe with specific people, revealing their identities in the process.

Indeed, participants varied in their reflections of how personal and private their own physiological data was:

P5: “The information is quite personal in a way”,

As opposed to:

P17: “Physiological data is not intrusive”.

Despite being steered with specific questions, six participants' first reaction was to comment on the comfort of the biosensor rather than the previously discussed privacy concerns. Four participants likened wearing the biosensor to wearing a watch, which is familiar and comfortable, for example:

P11: “Fells like I'm wearing a watch so I didn't really notice it”

(See also Appendix 12, reference 11).

Another participant considered wearing the biosensor uncomfortable due to its unfamiliar presence:

P5: “I'm not used to wearing something on my arm, on my wrist, so I'd probably not be very comfortable with it”

6.3 Summary

This chapter has summarised findings from the analysis of interview data with participants. The language of feel was explored with participants: how they currently communicate about clothing and how the website could help them in the future. Participants explained their interest in the physiological data collected and displayed on the site. They also articulated some scenarios when the website may be useful for them, namely deciding what to buy and wear. Ethics surrounding the
site were also discussed, where participants explained their feelings towards physiological data and sharing such information publicly. The next chapter will explore if the data collected on the site thus far indicated that a common language of feel could emerge.
7 Results 2 – Is there a common language of feel?

7.1 Analysis of the collected clothing descriptions
The data collected on the website was analysed to investigate if people understood each other's multi-modal descriptions of clothing and whether or not the crowd was too diverse to produce a common language of feel. Specifically, the analysis sought relationships between emotions, texture words, texture images and fibres.

7.1.1 Browsing
The data collected on the website was stored in a database and queried via the site itself for real-time analysis. Users of the site may browse a list of garments added to the wardrobe (see figure 8 below). The browse list displays all images associated with each garment: the uploaded photographs, the texture images selected by users, the date the garment was added and a link to the garment's detail page.

![Figure 8. Screenshot of a section of the 'Browse' list displaying an image of participant's jacket and the texture image chosen to represent the feel of the textile.](image)

Textile detail pages display all images, the created date and link again, plus the emotion and texture words, fibre contents, colours and any notes (see figure 9 below). The textile page also displays the physiological visualisation animation created for the user who added the garment to the wardrobe.
7.1.2 Trends

As well as browsing garments on the site, users were also offered some aggregate statistics regarding the crowdsourced wardrobe contents as a whole, (see Appendix 14 for detail of aggregate calculations). This included a breakdown of emotion and texture words selected by users as well as the overall fibre contents of all garments in the wardrobe. These analyses aim to investigate if there was a relationship between the words and images participants used to describe their garments.

The most frequently used emotion words associated with garments in the wardrobe were 'Interested' and 'Happy', (see figure 10 below). Of the available emotions words, some were not selected by any users of the wardrobemalfunction.org.uk website; 'fear', 'disgust', 'joy', 'shame' and 'contempt', mostly negative valence emotions. These emotion words may be missing due to constraints within the experiment: participants were requested to bring in casual tops which may not commonly cause, for example, 'disgust' in their owners. It could be assumed that if a garment induced a feeling of 'disgust' in its owner, that person would remove that item from their wardrobe. Another explanation may be that the emotion taxonomy used was inadequate: emotions such as 'disgust' may not be suitable to describe clothing.
The most frequently used texture word used to describe garments was 'Soft' (see figure 11 below). Of the available texture words, half were not selected by any users, including 'resilience', 'sleek' and 'grainy'. Again, these texture words may be missing due to the aforementioned constraints within the experiment. Another reason may be that, with only forty garments added by twenty participants, it would be unlikely to elicit one each of the forty texture words. A greater data set may be required to make conclusions here.
The fibre content of the wardrobe was mostly cotton (see figure 12 below). This abundance of cotton may also explain the frequency of high frequency of 'soft' texture word and 'happy' and 'interested' emotion descriptors, as discussed below.
The data was further analysed in terms of fibre contents to see which proportions of emotion words, texture words and texture image categories were selected for each fibre (see table 5 below). Participants associated the positive emotions of 'happiness' and 'interest' with the cotton garments in the wardrobe. However, the third most popular emotion for cotton was the negative emotion of 'boredom', perhaps reflecting some participants lack of interest in clothing and the website.

Participants described the cotton garments in the wardrobe most popularly as 'soft' and 'light'. This could suggest that cotton may generally be described as inducing a feeling of happiness and interest and a feel of softness and lightness. It should be noted that a single garment may be composed or more than one fibre at various percentages.
<table>
<thead>
<tr>
<th>Fibre</th>
<th>Emotion</th>
<th>Texture image</th>
<th>Texture word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Interested 23%</td>
<td>Smooth 20%</td>
<td>Soft 23%</td>
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<tr>
<td></td>
<td>Happy 23%</td>
<td>Warm 18%</td>
<td>Light 20%</td>
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<tr>
<td></td>
<td>Bored 20%</td>
<td>Rough 17%</td>
<td>Clingy 7%</td>
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<td></td>
<td>Proud 10%</td>
<td>Flexible 16%</td>
<td>Fine 7%</td>
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<td></td>
<td>Sad 8%</td>
<td>Stiff 10%</td>
<td>Supple 3%</td>
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<tr>
<td></td>
<td>Angry 7%</td>
<td>Cool 10%</td>
<td>Warm 3%</td>
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<td></td>
<td>Amused 6%</td>
<td>Thin 6%</td>
<td>Flexible 3%</td>
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<tr>
<td></td>
<td>Surprised 3%</td>
<td>Thick 3%</td>
<td>Crumpling 3%</td>
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<td>Coarse 3%</td>
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<td>Stiff 3%</td>
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<td>Flowing 3%</td>
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<td>Harsh 3%</td>
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<td>Cool 3%</td>
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<td></td>
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<td>Limp 2%</td>
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<td>Interested 46%</td>
<td>Thick 34%</td>
<td>Smooth 18%</td>
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<td></td>
<td>Happy 35%</td>
<td>Flexible 27%</td>
<td>Synthetic 18%</td>
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<td></td>
<td>Proud 10%</td>
<td>Smooth 18%</td>
<td>Soft 18%</td>
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<td>Sad 9%</td>
<td>Rough 12%</td>
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<td>Warm 9%</td>
<td>Rough 12%</td>
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<td>Smooth 43%</td>
<td>Cool 43%</td>
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<td>Rough 43%</td>
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<td>Happy 77%</td>
<td>Thick 77%</td>
<td>Soft 77%</td>
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<td>Proud 23%</td>
<td>Flexible 23%</td>
<td>Coarse 23%</td>
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<tr>
<td>Elastane</td>
<td>Interested 47%</td>
<td>Flexible 53%</td>
<td>Cool 33%</td>
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<td>Amused 33%</td>
<td>Thin 33%</td>
<td>Elastic 33%</td>
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<td>Happy 20%</td>
<td>Rough 13%</td>
<td>Fine 20%</td>
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<td></td>
<td>Rough 13%</td>
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<tr>
<td>Lycra</td>
<td>Interested 100%</td>
<td>Thick 62%</td>
<td>Fine 62%</td>
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<td></td>
<td>Thin 38%</td>
<td>Dry 38%</td>
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<tr>
<td>Acrylic</td>
<td>Proud 100%</td>
<td>Flexible 100%</td>
<td>Coarse 100%</td>
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<tr>
<td>Cashmere</td>
<td>Happy 100%</td>
<td>Flexible 100%</td>
<td>Soft 100%</td>
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<tr>
<td>Rayon</td>
<td>Proud 100%</td>
<td>Flexible 100%</td>
<td>Coarse 100%</td>
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</tbody>
</table>

Table 5. Table shows which proportions of emotion words, texture words and texture image categories were selected for each fibre.
Next an analysis was made of the one-to-one relationships within the data, namely texture image and emotion combinations, texture word and emotion combinations and texture word and texture image combinations. The texture image and emotion matrix below in table 6 shows that the most frequent relationship was the emotion 'happy' and the texture image category 'smooth'. This may suggest a selection bias in that participants acquire casual tops specifically because they are 'smooth' and make them 'happy.'

<table>
<thead>
<tr>
<th>Texture image / Emotion Matrix</th>
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<tbody>
<tr>
<td>Angry</td>
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<td>Cool</td>
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<td>Rough</td>
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<td>Thin</td>
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<tr>
<td>Warm</td>
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</table>

Table 6. Matrix of texture image category and emotions words selected by each participant. Key: cells contain the number of people who selected that row and column header combination. Blue highlighted cell denotes the most frequent combination.

The next matrix below, table 7, shows the relationship between texture word and emotion. This matrix shows that the most frequent relationship was the emotion 'happy' and the texture word category 'soft'. Seven participants selected this combination, suggesting a strong link between soft textiles and happy emotion.
### Texture word / Emotion Matrix

<table>
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<tr>
<th></th>
<th>Angry</th>
<th>Surprised</th>
<th>Interested</th>
<th>Bored</th>
<th>Sad</th>
<th>Amused</th>
<th>Happy</th>
<th>Proud</th>
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Table 7. Matrix of texture word and emotions words selected by each participant. Key: cells contain the number of people who selected that row and column header combination. Blue highlighted cell denotes the most frequent combination.
The data was also analysed in terms of matches between texture word and texture image selected by each participant. The texture images were originally sourced from University of the Arts London students and related to a sub-set of the texture words offered to users. The fact that users were not made aware of a link between the texture words and texture images means the texture images may have been ambiguously interpreted. When analysed, only two of the garments in the wardrobe had a texture word associated which matched the category of texture image. The detailed breakdown of texture word and texture image correlations can be seen in table 8 below.
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<tr>
<th>Texture word / Texture image Matrix</th>
<th>Cool</th>
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Table 8. Matrix of texture image category and texture words selected by each participant. Key: cells contain the number of people who selected that row and column header combination. Blue highlighted cell denotes the most frequent combination. Orange highlighted cell denotes texture word and image match.
The matches between texture word and texture image were for 'cool' and 'rough'. This may suggest that those image categories were more representative of their texture word than the other categories. For example, the instance of match between 'cool' texture word and was with a texture image of a collection of ice cubes. This correlation between word and image gave a precise indication of that participant's perceptions of her garment. However, it could be suggested that where texture word and texture image did not match, those participants wanted to create a richer description of each garment by choosing pairs of word and image which were not obviously correlated.

The most frequent texture image was 'smooth' and the most frequent texture word was 'soft'. Further, the most common pairing of texture word and image was 'smooth' word and 'soft' texture image category. There was at least one instance of each texture image category selected by users.

7.1.3 Test t-shirt
A special case arose during the experiment which would not normally arise in a crowdsourced task. Every participant in the experiment was asked to enter data for a single item of clothing, the test t-shirt control. Every participant added data for this item; all other garments were unique. Like the participants' own clothing, 'interested' was the most common emotion with 40% of responses. Similarly, soft was again the most popular texture word selected by participants with 25% of responses.

Compared to the items of clothing that belong to participants, the test t-shirt gave a smaller range of variation in answers. In contrast to the participants' own garments where boredom represented 19% of emotions, for the test t-shirt, boredom represented 35% of emotions. This suggests that participants were much more likely to have a negative reaction to the test t-shirt to which they have no previous connection or experience.
8 Results 3 – Physiological changes

8.1 Biosensor results

One aim of the research was to discover how people feel about seeing and sharing their physiological data. To achieve this, a biosensor was used to collect participants' physiological data during qualitative research. Biosensors measuring physiological changes are helpful in detecting emotions as the data is collected while a person is experiencing the emotion rather than after the event. The biosensor available for this project did not have a wireless connection, so the physiological data representation displayed to users was not actually their own real time data. Despite the collected physiological data not being a focus of this investigation, it will be discussed briefly due to its relevance for future research.

Picard & Daily (2005) point out that GSR and body temperature are not socially communicated. Sensing these physiological changes and visually representing them to users of the website makes the invisible visible. Laypeople will not be able to interpret changes in GSR and body temperature, so they must be assisted in making sense of these measures. GSR and body temperature changes do not directly relate to isolated emotions, so care must be taken not to mislead users into thinking that these measures reliably correlate to discrete emotions.

8.1.1 Why GSR and body temperature?

The Affectiva wrist mounted Q Sensor biosensor was used to collect galvanic skin response (GSR) and body temperature from participants. GSR, measured as electrodermal activity, is a physiological measure used to infer an arousal reaction in people. However, GSR changes may also be triggered by non-emotional changes in a person and it cannot detect whether the arousal is of a positive or negative valence. The biosensor used also collected body temperature changes which can be used to infer the valence of emotional changes. So a combination of GSR and body temperature changes should have been a useful tool to triangulate with participants' emotional self-report.
8.1.2 Which biosensor?
The wrist mounted biosensor was selected as it left participants' hands free for handling and feeling fabrics. Other finger mounted sensors have been reported as more sensitive due to greater GSR response on palmer surfaces (Edelberg, 1961), however such sensors could hinder movement and cover sections of the wearer's fingers, inhibiting garment handling. For the purposes of this investigation, where accurate physiological readings were not necessary, the trade-off between comfort and accuracy was considered appropriate.

As previously discussed in the Results 1 section, six participants of the qualitative research mentioned the relative comfort of wearing the biosensor with some participants reporting they had forgotten they were wearing it.

8.1.3 Results
One participant's biosensor data file became corrupted and so was excluded entirely from any analysis. 16 participants' results were negligible and therefore unusable. Only four participants had fluctuations in the biosensor data, however there were unexplained troughs in GSR levels, which suggested the data was unreliable. All participants whose data showed fluctuation were male. There were many possible reasons why so many participants' physiological data showed no significant changes and will be discussed in the Limitations section. See figure 13 below for example biosensor reading.
Summary

Participants did not complain about discomfort when wearing the biosensor and they were able to freely handle clothing during the experiment. However, the biosensor used did not have a wireless connection, so real time display of physiological data to participants was not possible. The results of collecting the physiological data for later analysis were unusable and thus disappointing. This sort of biosensor is not appropriate for studies where physiological data must be gathered for subtle emotional reactions.
9 Discussion

9.1 Research questions

This chapter will discuss the results of this project. The main research question will be addressed as well as the two secondary research questions.

9.1.1 Can a crowdsourced emotional wardrobe support the development of a language of feel?

A website such as wardrobemalfunction.org.uk may be a useful surrogate experience of touching fabrics. The digital language of feel used on the site may help communicate remotely and across languages as a visual emphasis is employed, as mentioned in the contextual inquiry interviews with designers in chapter 4.

People may be increasingly willing to share online probably due to the rapid recent popularity of social networks such as Facebook and Twitter. Participants of this study were willing to share their physiological data: six were willing to share with anyone, and twelve were willing to share with caveats such as “only with friends”. Hook et al. (2008) discuss the importance of empowering users in relation to their own physiological and emotional data, a finding which also emerged as a theme in this project's interview data. The wardrobemalfunction.org.uk hypothetically tries to sense physiological changes automatically, so the only control users have is a choice not to wear the biosensor. However, users are anonymous which lessens the need for autonomy, although there is a risk that people may be identified by their clothing. One solution may be to require users of the site to login. However this may be an obstacle for use which would lessen the potential of crowdsourcing.

Participants revealed a theme of decision making when thinking about uses of the site. They wanted to use the information on the site to help them make informed decisions about what to wear or what to buy. Those who wanted to decide what to wear, the 'contributors', wished to add information to the site and then share this with specific friends or family in order to get feedback. This sharing would not only create a use for the website and increase loyalty, it would also spread word of the site and hopefully associated new users. 'Consumer' users would prefer to use information on the site to help them make informed decisions about what to buy. This information would be best
sourced from an existing e-commerce site where people are already making buying decisions.

The experiment was conducted with twenty participants: too few to establish reliable language of feel trends now, but if the website gains traction or “goes viral” it may indeed offer insights into how people communicate a language of feel. For the website to become popular, it must be easy to use, engaging and appealing to users, offering its users some benefit for taking the time to add their own content.

As Rode (2011) suggested, technologies should be used to complement existing social encounters. Participants in this study explained that they already remotely communicate with friends and family regarding clothing via social networks and phone conversations and that these experiences are somewhat lacking. To improve the chances of a large and diverse user group, the crowdsourced emotional wardrobe may be best situated within an established digital space such as a social network or e-commerce site. This would exploit the existing loyal user base and easily fit in with users' social habits.

9.1.2 What will people make of a representation of their physiological data?

Emotions are ambiguous: both sensing and interpreting one's own emotions and interpreting others' emotions. Emotional attachment or reactions to clothing are subtle, so the physiological visualisation was designed to be subtle. Physiological data is an indirect measure of emotion; the visualisation reflects this. However, a number of participants mentioned a preference for graphs of physiological data. They wanted to see how data differed across time, items of clothing and people. Perhaps using the science term “physiological data” with participants biased them into wanting a scientific graph. It may be best to exploit ambiguity until biosensors are more accurate. Sparklines (Tufte, 2001), purposefully minimal graphs with no labels, axes or scales, may be a useful compromise between ambiguity and clarity.

Conversely, the wardrobemalfunction.org.uk site compelled some participants to dig deep regarding the ambiguous aspects of design. Those participants responded positively towards the texture images: using the selection of an image to creatively think about their experiences of a garment, and using other peoples' choices of texture image to infer the experiences of the other person. Clothing
described in terms of emotion is a novel interaction which forced participants to view their clothing in a new light. Many participants reported an epistemic curiosity towards the contents of the site. Satiating curiosity is pleasurable, so this may help attract users and encourage repeat use.

There is a possible short-coming of any future attempt to triangulate physiological data with the self report of emotion regarding clothing. That is, the physiological data relates to a person's current affective state when handling and thinking about a garment. However, self report of emotion may not relate to the present moment but a memory related to a garment. For example, if a woman were to handle her wedding dress she may think about how it feels currently and this would be reflected in her physiological data. However she may select 'Joy' as her emotion when questioned, as she remembers the joy of her wedding day. Such conflicts and temporal dissonance must be acknowledged and addressed. Storytelling in relation to garments may be a solution, (discussed further in Future Work, in chapter 10).

As discussed in Boehner et al. (2007), there is no direct and concrete representation of emotion via physiological data, so the website creates an ambiguous abstraction by displaying it as a fuzzy visualisation. By presenting the physiological data this way, it makes this objective measure subjective. Emotions are complex, and perhaps asking participants for a single word from a set of 12 was too simplistic. It could possibly be improved by including a larger or more appropriate emotional taxonomy, allowing more than one emotion to be chosen or scalar choices. However any additional work asked of users introduces a usage obstacle.

9.1.3 How do people feel about crowdsourcing such data?
The success of any crowdsourcing system relies on an abundance of valuable content. Such content is provided by the crowd, and results of this project indicated that only 35% of participants would be motivated to contribute content to the site. However, 65% would be interested in using the content on the site to help make decisions. This combination of contributors and consumers makes the wardrobemalfunction.org.uk a promising prospect for success.

The results of this project suggest that many people seek out and rely on opinions of trusted friends with regard to their choice of clothing to buy and wear to specific occasions. Contradictory to this
research, Rode & Harris (2005) reported that their participants expressed an independence in that they did not care what their friends thought of their clothing. This could be due to cultural differences; the Rode and Harris research took place in the USA whereas this project took place in London, UK.

As highlighted in the literature review, Tomasic et al. (2011) propose that information for the crowd is generated by the crowd, so crowdsourcing requires a minimum level of activity to be self-perpetuating. Tomasic at al. also highlight the problem of incentivising use of crowdsourcing sites. Perhaps participants in the qualitative research for this project were enthusiastic due to the monetary incentive offered for participation. Also referred to in the literature review, Tomasic et al. suggest that an exchange incentive may be a solution, whereby users are not allowed access to content until they have provided content themselves. However, from the results of this project, it would inadvisable in this situation as only six participants expressed an interest in being both a contributor and consumer of the wardrobemalfunction.org.uk site.

Wardrobemalfunction.org.uk is a collective wardrobe, not individual like the existing intelligent wardrobes that past research projects have developed. Previous intelligent wardrobes have been based on algorithmic outfit recommendations. Focus on crowdsourcing could offer different or better solutions than algorithms. Crowdsourced solutions have the potential to change organically according to fashion trends and seasonality without adjustment. Crowdsourcing a wardrobe is very different to an individual wardrobe; it will contain a mixture of tastes, sizes, genders, seasons and locations. If use of the site were to “go viral” there may be enough content of the site to fully establish a language of feel. Of course, “going viral” carries its own risks including misuse and abuse. Perhaps controls and moderation mechanisms should be in put place to counter such risks.

Morris (2011) discusses that offering people the ability to regulate emotions (up-regulate positive emotions and down-regulate negative emotions) may be beneficial to people's wellbeing. Cognitive reappraisal involves reframing thoughts or situations so as to decrease their emotional impact. Wisdom of the crowd may help here, either by specifically recruiting Mechanical Turk workers as suggested by Morris, or perhaps by creating a crowdsourced store of emotional data, such as wardrobemalfunction.org.uk. Users may also feel an altruistic urge to help others perform cognitive reappraisal based on their own data added to the site.
9.2 Limitations

9.2.1 Website design
Some participants of the experiment reported a difficulty in selecting only one, or any, emotion in relation to their clothing. A more appropriate emotion taxonomy may be required to allow people to adequately articulate their feelings towards clothing. One way to create an appropriate taxonomy would be to allow users to choose from the existing list on the website or add their own words. This would essentially crowdsource the emotional taxonomy.

9.2.2 Experiment
Some participants had very strong accents and were difficult to understand at times, despite reporting English as their native language. It was considered unethical to question their statements, so the experiment was conducted regardless. However, this may have skewed results, perhaps accounting for unexpected results in the website aggregate analysis such as describing a viscose (synthetic) garment as having an 'organic' texture.

As Charmaz (2006) points out, longer interviews may have resulted in richer data for the grounded theory analysis. However, due to time constraints, all interviews were limited to twenty minutes. Shorter interviews sometimes recorded, as some participants were less articulate or engaged than others.

Ideally, participants should have be pre-screened to include only those who are particularly interested in clothing. This was not possible due to the difficulty of screening for such proclivities; if participants were asked to attend only if they were interested in clothing, they may have attended regardless of their true attitudes because of the incentive offered. Such behaviour may have resulted in biased interview data, as participants would feel the need to give evidence of their interest in clothing, but would not be truly representative of their thoughts and feelings. To avoid these problems, a convenience sampling model was used with no pre-screening of clothing interest.
9.2.3 Qualitative analysis

The interview data was coded in three passes: a first grounded theory based analysis, followed by an analysis using an affective framework and finally an analysis to collate the findings and form themes from the codes and categories. Grounded theory was conducted first so as to not bias this analysis with knowledge from the affective frameworks. However, the researcher had prior knowledge of affective frameworks which may have affected the initial coding nonetheless.

The affective coding highlighted many of the same words and phrases from the transcripts as the grounded theory. This could be explained by inefficient coding, but the affective framework offered structured ways to think about the codes and framed the coding so as to elicit additional and deeper insights into the participants’ experiences.

9.2.4 Biosensor

The data collected by the biosensor was disappointing and this may be due to many reasons. The biosensors were used in a lab environment with low ecological validity, so participants may have felt disengaged. During the time in which participants were handling items of clothing, it was impossible to accurately tell if they were actually thinking about the fabric. They could simply be touching it but detached or distracted. Perhaps 'think aloud' of the fabric feeling process may have mitigated this. However, such a process may be embarrassing or too pressured for some users.

Alternative biosensors could be considered instead of expensive wearable sensors. Webcam heart rate detection may have been an alternative (Poh, McDuff, & Rosalind W Picard, 2010), as it has a lower obstacle of use than a wearable sensor. Such a method integrates nicely with a website situation, i.e. many home computer users already have webcams. It also avoids users having to wear specialist equipment, meaning more participants could take part, even remotely, and participants would be less aware of being monitored. However, webcam heart rate was not available for this project. Additionally, there is the ethical issue of participants needing to be fully aware of being monitored.

Participants were asked to bring along 'casual top' items of clothing. There was no request for clothing with any particular emotional attachment. Perhaps asking participants to bring a favourite item of clothing may have elicited significant physiological changes. However, a favourite item of
clothing across twenty people could have resulted in too diverse a group of clothing where homogeneity was preferred.

The biosensor itself may have been at fault. It may have been faulty or only intermittently working as the majority of users recorded little or no change in GSR or body temperature. The wrist location of the sensor is also not as accurate as other similar sensors.

9.2.5 Ethics
Care must be taken when monitoring users that data amounting to personality traits must not be built up as this may make users vulnerable to discrimination. Emotions related only to clothing should be captured. Users must be aware of these safeguards to feel safe and comfortable using the system. Picard & Daily (2005) point out that some physiological data may be collected from people without their knowledge so as to avoid extra stress caused by a feeling of being monitored.
10 Conclusions

10.1 Future work

The next step of this project will be to release the site to the general public and ask for content submissions. This should collect a larger set of data and hopefully significant trends will emerge, outlining a digital language of feel. This was not possible within the scope of this project due to lack of copyright permissions for some images within the texture image set used on the site.

In order to determine whether physiological visualisation may help people to communicate about clothing, a real time biosensor should be tested. Another experiment could compare a more scientific graph of physiological data versus an ambiguous visualisation and identify which is preferred.

To extend the crowdsourcing theme, the site could allow users to query the database themselves and then share any interesting results publicly. As Rode (2011) encourages feminine technological empowerment, the wardrobemalfunction.org.uk site could aid programming skills amongst its users.

Potential future work on the site could include creating private, individual wardrobe spaces with only the aggregate data shared publicly. This could aid users in cataloguing their clothing in much the same way as wardrobes already developed (Shen et al., 2007) and (Cheng & Liu, 2007). As users would need to sign up and login to the site to access their private wardrobe, this approach may create usage obstacles. However, if integrated within a social network, signing in via technologies such as Facebook Connect authentication (“Facebook for Websites - Facebook Developers,” n.d) may make this task easier and quicker.

Creating individual wardrobes would also offer the opportunity to segment the wardrobe contents (e.g. differentiating between designers versus laypeople). Nickerson et al. (2011) suggest that the use of experts within crowdsourced systems may offer more informed evaluations. The designer language of feel could differ from that of the layperson in unexpected ways. However, the laypeople's language may not overlap at all, as seen with some texture words used on the site. These results suggest a lack of downstream validity; if the language of feel is not representative of
laypeople then they may be less likely to use it.

Other future work could be to encourage recording of memories associated with clothing as a storytelling archive. As discussed in the previous chapter, temporal dissonance may affect users' current physiological data compared to their memories of significant past events associated with a garment. The date associated with garments could be an important feature when browsing the wardrobemalfunction.org.uk site as time passes and trends come and go. Personal memories and a knowledge of when that story was told could create a greater emotional connection with clothing from a consumer point of view. One of the clothing designers interviewed during contextual inquiry described a t-shirt as: “That vintage vibe”. Such succinct phrases may add depth to the garments within wardrobemalfunction.org.uk.

10.2 Summary
The criteria set out by Zimmerman et al. (2007) with regard to a successful design research project are to document a process, as shown in the Method section. Design research projects should demonstrate invention, in this case a combination of an emotional wardrobe with crowdsourcing methods. The project should also be relevant; crowdsourcing may offer a solution to a missing language of feel. Lastly, Zimmerman et al. suggest extensibility is essential, in this case, this report and the website stand as documentation and design artefact.

McCarthy et al. (2005) note that, in order to foster lasting enchantment, a technology has to have depth. Such depth may be better derived from crowdsourcing rather than computer algorithms. In the same way that Stead et al. (Stead et al., 2004) channel communication between humans via garments, the wardrobemalfunction.org.uk site channels communication between humans about garments via the website. The tactile is not a sense that is catered for digitally, unlike the visual or aural, but it is an important sense relating to clothing. The wardrobemalfunction.org.uk website attempts to make the invisible visible by offering people a way to judge a garment according to other remote peoples' emotional reactions. Nothing beats handling fabrics, but if this is not possible, the wardrobemalfunction.org.uk website may be of use.

Clothing designers may wish to co-design with consumers in order to target users' needs more
directly and personally. Contextual inquiry as part of this project showed that designers do not currently communicate directly with end-consumers, but could benefit from doing so. Designers could also employ a common language of feel when communicating with textile suppliers. Researchers need a language of feel in order to further explore the area. Laypeople's reactions to textiles may be useful for themselves and others. This project has investigated the needs of some user groups and created a tool to aid the development of a multi-modal digital language of feel.

Most participants of this project's experiment responded positively to the wardrobemalfunction.org.uk site and expressed a view of it being useful for them. For maximum benefit and perhaps for commercial use, such a system should be integrated into existing behaviours such as shopping on e-commerce sites and deciding what to wear via social networks. It may be necessary to refine the set of texture images used on the site, or use different taxonomies for the emotion and texture questions in order to improve articulation of textile perceptions. If people find the site useful, it should lead to ample content and therefore successful crowdsourcing. The more content, the greater the opportunity to reveal a digital language of feel.
11 References


Rode, J. (2011). Dressing as the Lion or the Witch in the Wardrobe. *In press*.


Appendix

Figure 1. Example experiment interview transcript of participant 19

Q. Would you say you were particularly interested in clothing or fashion?
P19: I have an interest in it, I wouldn't say I'm a super fashion crazy person.

Q. How did you feel about the information we asked for on the website?
P19: I felt, I liked the picture. I think the picture was more evocative to me than the words.

Q. Choosing the picture, or you taking the photo?
Choosing the picture, rather than the feeling word that would be more difficult.

Q. Of the questions we asked, which do you think best represents the tops that you brought in?
P19: The questions on here? Maybe the picture.

Q. And which least represented the tops that you brought in?
P19: Probably the colour.

Q. Did you find any of the questions particularly interesting?
P19: I liked the picture thing because the pictures were not what you would expect them to be, but they were very evocative about things that you couldn't, that weren't actually the same as what the words were. So I thought that was useful.

Q. Was anything not interesting to you?
P19: Maybe the fabric composition. I don't think I'm into exactly, what exactly it's made of. Its not exactly clear what those things necessarily mean. You can get a cashmere sweater and it doesn't really feel like a cashmere sweater.

Q. How do you feel about sharing that information online?
P19: It doesn't bug me. It's not super intimate kind of information.

Q. We have been gathering your physiological data and what did you think of the visualisation we showed you?
P19: Visualisation?

Q. On the right hand side there was an animation.
P19: This little thing.

Q. Yep, did that convey any meaning to you?
P19: I remember liking the second one better than the first one. This one is orangey and I liked the orangey one. The first one was like blue. I didn't like the blue as much.

Q. Was it the colour you were looking at?
P19: It was, I guess the colour and the shape was different also on the second from the first time. I think the colour was the thing I noticed. I guess the colour and the form together was what...
Q. Can you relate the visualisation at all to your physiological information?
P19: I mean maybe, I don't know if I mapped it directly on to how I was feeling.

Q. Would you prefer to see your physiological information in another form?
P19: Perhaps, I don't know what another form would be like. Would it be like a graph? Like, what are the kinds of ..?

Q. What would you prefer to see it in? What do you think would have most meaning for you?
P19: To draw my attention to it and make me think about it?

Q. Whichever would be useful for you.
P19: Because this, I was like, what an interesting little thing. But I wasn't engaged with it very much. If I was supposed to engage with it, maybe something that seemed a bit more scientific-y. So it would be a graph or some sort of science looking thing.

Q. What would you be looking for in your physiological information?
P19: I don't know, maybe just seeing either how extreme it was or how, if it were very one way or the other I think I would notice it more. I think if its middle of the road I'm not sure you notice it as much.

Q. How would you feel about sharing your physiological information online?
P19: In what context, would it be attached to something like this or?

Q. Generally and specifically. Would it make a difference if it was like this or not?
P19: This would not both me at all. I think if there were no way to know exactly who it was I think I wouldn't have an issue.

Q. What about if people could identify you?
P19: I think that would be a little, it would depend who could access it I think. If it were something on Facebook where you could decide who has access to that I wouldn't have a problem with it. If it were anybody and their mum could see it would be different.

Q. What groups of people would you feel comfortable with seeing it?
P19: Friends, just... I'm not sure its really super dispositive of your personality or anything. But certainly not employers or just in terms of anyone who, like might see it as something like your personality or, a little too intimate kind of stuff.

Q. How would you feel about wearing the biosensors for a longer period of time, or regularly?
P19: Doesn't bother me.

Q. And sharing that information?
P19: It would depend with whom again. I almost feel like that might be less weird. Because I think the variations would be ok. The exception would be if it were really extreme in some way, where it might make one seem somewhat unbalanced.

Q. Can you think of a situation where you seeing your physiological information might be helpful to you?
P19: In terms of stuff like this or just in general?
Q. In general.
P19: I'm trying to think of, yeah I think its, I tend to get migraines and stuff and so I think that bio-
feedback-y kind of stuff is actually useful to know because you can kind of feel it but in terms of
being able to see, 'oh look what happens here', I think it may make you more aware.

Q. Now, in terms of this information, can you think of a situation when that might be useful?
P19: In terms of the, I can see the linkage between your mood and objects and the interaction, you
can see how, 'yes you're really agitated, what can you do', I can see how that would be, you know,
oh you picked the one that made you seem happy. So things like that I could see as a soft
mechanism to calm people without having to be all crazy about it.

Q. Would you like to see other people sharing information about their clothing online?
P19: Maybe. I think it's interesting to see where people, you know in terms of fashion blogs. 'Oh
why did they think that was a good idea?'. I find it just interesting to see what people would do but
I'm not sure I'm necessarily influenced by it but in terms of, it is kind of a weird way to engage with
people about things where you figure out a little bit of what's going on in their head.

Q. Would you be particularly interested in a certain question we asked from other people?
P19: Actually, again I think the picture thing. Because I think you evoke a certain feeling by looking
at the picture, it makes you feel like something. And so I think if you found someone else who had
the same kind of picture feeling as you then you would probably know, there would be a similarity
between how you perceived how it would be much more similar than if it was like, 'how did it make
you feel', you know? I think that's a little less positive.

Q. Would you be interested in seeing other people's physiological information?
P19: Maybe. I'm not sure it would be, like if it were in terms of would I like to have the same item,
I'm not sure it would be decisive for me. I think it would be interesting, especially if you are like,
'Hmm, is it scratchy and fuzzy?'. In terms would that be how I expect to feel about it, I'm not sure.

Q. Can you think of a situation where the information we asked you for today about your clothing,
when that might be helpful to you?
P19: I mean, aside from the dressing to influence one's mood, which I think is a useful thing to do.
Let me think. Or I guess the way other people react to you, the personal ones can influence how you
feel about it, but perhaps if you are trying to get a reaction in people, perhaps knowing that this
particular item incited this particular feeling. If you wanted to have that attractive reaction.

Q. Would you use this website?
P19: Maybe, I'm not sure if I would use it consistently but every now and then I would find it
interesting.

Q. Where would you use it from?
P19: What do you mean where?

Q. Location or context.
P19: I assume in my house. Although I suppose maybe iPhone shopping kind of thing would be
useful as well. But yeah, just in terms of thinking about how either, yeah I online shop a lot too so I
could see, especially online shopping I could see it would be kind of... If you were trying to get a
sense of what something would be like without actually having it there. So if there was an image
that looked like very similar to what you were gonna get and you were like, 'Hm, don't know if I'm gonna like this or not'. That might be useful.

Q. Can you think of a situation from your past when this information or this website may have been helpful to you?
P19: I do think the physiological, the what do you, or how does it make you feel things, so if you are really upset you can be like, 'what made you really happy that time?'. Being able to maybe catalogue, especially if you had the physiological information, being able to know, 'Oh look, heart rate down.' In terms of maybe dealing with an emotional situation or something.

Q. Today I asked you to take photos in here, if you were to use the site at home, how would you take photos at home?
P19: I dunno if I would be super formal about it.

Q. Would it be the same as you did today?
P19: Maybe so. I think just the environment of being at home is different than having to be remarkably different in general.

Q. I'd like to go back to the website now to show you the sorts some of the clothing other people have added. So have a browse, click wherever you want and talk me through your thought processes. What catches your eye, what you are clicking, why you are clicking and what you are looking at as well. Feel free to have a look at whatever you like.
P19: The neckbrace, I was wondering who would use the neck brace! Yeah, doesn't make me want to know any more about that particular item of clothing. The crazy shirt makes me laugh a little, and I'm not sure what it has to do with, what is that, a shirt? I don't even know what that is. Yeah, I don't know and I'm not sure I would think that had anything to do with that. That also doesn't seem pleasant to me. I think if I saw that I would be like, 'You know, I kinda like that one.' I like the pattern of it, it looks like something exploded but it's actually a leopard or something. Yeah, there's something about the scheme of it which makes me... Again, I'm not sure I have the same feeling. I used that image and I, that's not what the image felt like to me. That is more like what the image felt like to me. Kind of fluffy. This, it wasn't the natural-ness of the image that drew me to it, it was the fuzzy edge of the little ferns.

Q. When you scan through, what are you looking at or for?
P19: I don't know, I'm looking for something that strikes me. Like this one made me think of cosiness. And I do think that the images made me think about the other images differently than I would otherwise.

Q. What do you mean by that? The fact that you had to choose one first?
P19: No. I mean the thing about the image, what does the image evoke for me and based upon that I feel like I perceive whatever is next to an image I might like. For example the one that had the crazy neck brace thing just seemed so jarring, unpleasant, just makes me feel like... Even if there was a different picture here I would totally think differently about it.

Q. Do you think its useful to have those mood images?
P19: I do. I'm not sure it would necessarily always agree with the ones chosen, but I think it gives you a sense of what, kind of, yeah its kind of what it feels like. I mean I think its more expressive to me than having just a word of someone saying, 'This makes me feel like this'. Because I can look at
Figure 1. Example experiment interview transcript of participant 19 cont.

this and say this is how I feel about that image. Even if I don't agree with it I do get a sense of what is going on in that image in a way I don't think I do from the words. There's something about this particular image and then the image next to it that seem very like, it made me think about the kind of shape and the flexibility of what was going on. I think it was a little bit different than what it would have been with some of the other ones. Yeah, I don't think I would want one that was like cardboard.

Q. How do you think yours compares to other people's?
P19: I think they are equally personal I think. There is something very personal about the linkage between what pictures you put with what. I don't think its just, 'it feels like this'. I mean, some of them I think are but then some of them are like this. You see there is a connection that's happening in somebodies mind that's necessarily like, 'this is what colour it is', I think its a much deeper connection than that. I think its almost more helpful the pictures don't directly map on to anything and you have this sense of the personal associations that come through.
Figure 2. Example coding using grounded theory and affective framework

Grounded theory codes

Affective framework codes

Grounded theory coding example

Affective framework coding example
Figure 3. Example photos from contextual inquiry with clothing designers

- Tech pack instructions to textile supplier
- Swatches from a textile supplier – note that some swatches have been trimmed in order to post samples
- Design inspiration folder viewed in iPhoto
Q. What sort of materials do you collect?
A. Labels, canvas, PU polyurethane materials and all the leather swatches and little bits I get sent by suppliers. Usually if I like a fabric from a vintage piece, or if I need to throw away an old t-shirt, I always keep the label for it.

Q. Just the label?
A. Yes just the label, or if there was a good graphic I would cut that out and keep it. But that's got more to do with the graphic, the finishing of it rather than the actual cotton material. Unless it was a cool swatch of a short design or something.

Q. Where do you source your collections from?
A. Its all my own. Sometimes I go to charity shops and buy the cheap options so I don't end up spending a fortune on materials.

Q. The bits that suppliers send you, do you request those or do they send you catalogues?
A. I send them a brief based on my research for the seasons, first I look at colours and then I look at trends and then I go online and look at different websites for textures and materials that I think match those trends or that I think will work. Then I break it down into the different categories that I want, so I work with belts so it would be Pus, leather looks, leather, webbing materials, appliqué fabrics and then I send it over to them and then they go away and usually send me a big box. This is the smallest box I've received. I only received it two days ago. It was quite nice actually, they seemed a bit more focused. Sometimes what they send is horrible. I recently had a cull actually. Some stuff they send you can be really bad.

Q. So they send you boxes?
A. Yes they send big boxes.

Q. Is it once in a while?
A. Its lots. Basically we have an agent in Shanghai and they talk to the factory and the factory go out to the fabric market in Weng Shang(?) in China and in the fabric market - I've been there actually, it was really good. That was the best because then you can choose your own. Actually going to all the stalls. Many of them have fabrics which are quite similar, they have slight variations on the finishes of them. Best thing about that was the multitude of checks. You could pick exactly what you wanted straight away because you could see it but otherwise you have to choose from twenty and narrow it down. Usually that's the process.

Q. So would you communicate via email with the agent?
A. Yes and then the factory send it directly to me now, to save time.

Q. When you went to the market, did you collect anything then?
A. Yes, the materials we looked at there, we were taking photos, buying and getting cuttings of different check fabrics and appliqué. Getting lots of new swatches. They have contact details on the cards so if you have the name, like Room Ming or whatever they are called, then you have got the reference number, then you have got the number of the swatch and they are stapled onto the card. So you cut out and keep one piece for yourself and send the card to the factory.

Q. What do you collect the swatches for?
A. Some of it is for research. Obviously I keep the nicest ones always. I think its mainly to say, 'I like this one, I want something similar to this'. They might not have the exact one. Its not really for inspiration. Research always renews itself every season.

Q. What do you need to know about a fabric? Fibre content maybe?
A. For me, because I work, because I haven’t worked that much recently with clothing.

Q. Even with belts, would you need to know the composite material?
A. Usually that’s not something I have looked into. We have talked about doing vegan, and other materials but <brand he works for> is unfortunately not concerned with that. So I can't really look at that much detail in that. I know, I can usually feel and smell. The ones that smell least plasticy, they are the ones I usually go for. Ones that feel less synthetic, basically I want something that is a close to leather as possible. Without being like suede or having that cheap feel. There is quite a fine balance.

Q. How would you identify different materials? Is it just feel and touch?
A. Yes, touch and I look at it in different lights, so daylight and indoors as well. It always changes a little bit.

Q. When you find a material, what would you keep?
A. Depending on where I am I sometimes have to take a photograph but usually its always better to have something you can feel so I would try to take a cutting if you can.

Q. Where do you store them?
A. A box. Basically Ikea boxes, plastic ones. I keep too much stuff.

Q. How do you organise them?
A. I have one bag for labels, one box for fabric swatches, one bag for metallics and different metals, different finishes.

Q. Do you organise them within the boxes or just pile them in?
A. Bit of both. With the labels they are quite well organised. Actually I collect lots of paper samples because I do print as well, so paper labels are kept separately. They can be for research and inspiration as well. They are kind of categorised. If you had one in your mind and you had to find it, would you know where they are?
A. No, I would have a bit of a rummage through.

Q. Do you ever need to communicate samples with anyone, do you ever send them out?
A. Yes, I will show you. I would cut them off there, the fabrics from fabric books and I would write underneath the reference code and I would keep a cutting for myself and send this out to them so its quick for them to identify. The sooner they can identify the fabric manufacturer.

Q. Would send send it by post?
A. Courier.

Q. Is it always to China?
A. Yes.

Q. Would you ever email about the swatches?

Figure 4. Example contextual inquiry interview transcript of participant 1 cont.
A. I have done in the past, because the factory will not send out duplicates so they will need to physical swatch to make proper identifications. Its never enough to have one picture, because of the quality of light when they shot it, its not good enough.

Q. If you sent them something and you have to identify which one you mean, so that one instead of that one <points>, how would you do that?
A. I would say, this is referenced on the artwork sheet so that code, they supply the codes, but I designate the name. I always give them a name as well, so I always mention the name I have given them which is also on the artwork sheet. So I give all the colours and fabrics as that's easier for me too.

Q. Do you ever collaborate with other designers?
A. I do from time to time. With that, if you wanted to be more practical, because I am working on some t-shirts with America now, for another brand so we are working on four t-shirts and it will be a really small range so it doesn't make sense to dye up fabric for this. We are using the same manufacturer and colours that they do. I just need to coordinate with them to make it more practical.

Q. Do you speak on the phone? Or just email?
A. Email.
Q. Do you send t-shirts to each other?
A. No, we haven’t done that, as its just prints.

Q. How often would you go through the bags and boxes?
A. Whenever I make something new. It seems to help to send out a tactile reference.

Q. When you need to get something out, would you take the whole bag out?
A. Sometimes I don't really know what I want and I’ll go through to find something good for this idea.

Q. Would you judge them by the material or colour?
A. Usually its the finish that I am after, so nice hand feel. Sometimes its just the print, sometimes its everything that you reference. Sometimes its the weight. Its just easier to get across to give a reference like this.

Q. How do you know how to describe the feel of one of these?
A. Its just through experience. I haven't studied fashion before. I wish there was a book, its hard to describe all these things so a book would be useful for how to talk about fabric. I've never seen a book that goes into detail of hand feel of textiles. There are so many technical little details that I don't know. You just have to go with what you think is right, what you think sounds right. I collect other stuff for research and inspiration like old postcards and that kind of stuff. That's a bit different.

Q. Do you just store everything like this, or would you store anything on the computer?
A. I store a little bit on the computer. So I look at blogs and store photographs of things I like. Its patterns and things that inspire me.

Q. So would you go out on a specific research trip?
A. You do that sometimes, but you can see the sorts of things that I like, like this one is just on the street.

Figure 4. Example contextual inquiry interview transcript of participant 1 cont.
Q. How are these organised?
A. These aren't categorised, these are stored by date. So I just look at the colour of it.

Q. Is this stuff you found online?
A. Yes.

Q. Does iPhoto store them by date automatically, or did you choose to store them like this?
A. Well these are patterns and these are things that I have found. This one is textures and this is more graphics.

Q. How would you find something in here?
A. I would go back and forward like this, but it would be better to have a structure for it. So I could do a search for something, like crests and the crests would come up or gold text on spines.

Q. Do you often to go and find something but you can't find it?
A. Yeah actually, when I try to find something specific I might not. But I have another library that is basically more ordered. So this uses tag words.

Q. Do you find that easier?
A. Yeah yeah. But iPhoto is much more visual so its easier to use, a lot easier to work with.

Q. So how would you reference this?
A. This is the sheet and this is the reference.

Q. So is this all the same material, just different colours?
A. Yes.

Q. So how would you request these?
A. I'll show you my spec sheet. Thats how I got these fabrics.

Q. So you just know that this material is called webbing?
A. Yeah.

Q. Why did you get these fabrics? Is it because they don't have it in that green?
A. Yeah, they send the closest they have. I have no other option, they just send me what they have. I'll probably go with that one because we already have something that colour in the range.

Q. Would you decide by colour alone?
A. No, the feel and the weight too. And this one, it has to go through a belt loop and it wouldn't lie flat.

Q. So you think about the construction too.
A. Yeah.

Q. Would you need to think about cost?
A. If there was a quantity issue, like for a suede they would notify me if there was a minimum order for anything. They would have metallics too, here.
Figure 5. Entity relationship diagram – website backend database architecture

Key:
NN = not null column
PK = primary key
FK = foreign key
AK = auxiliary key (unique constraint)
Figure 6. Design process photos: sketches to wireframes – using pencil and paper, Mockingbird and Axure
Figure 7. Example texture images as supplied by University of the Arts London students. (Sourced from lovetextures.com and free for use under the creative commons attribution 2.0.)

Figure 8. Experiment questionnaire and ethics consent form

**Participant Questionnaire**

Participant Number: P_____________

Participant Age: _______________

Female:____ Male:____

Is English your first language? _____________

Are you fluent in English? _____________

Have you bought along two 'casual top' items of clothing? _____________

Occupation: _______________________________________________
(If student, please write your course name and year of study)

Have you ever used an iPad? _____________

Have you ever used an iPhone? _____________

Email address to send Amazon £20 voucher to ______________________
Information Sheet for Participants in Research Studies

Title of Project: Digital Sensoria

This study has been approved by the UCL Research Ethics Committee: MSc/1011/006

Name, Address and Contact Details of Investigators: Lucy Hughes, Liina Martonjak

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, it is important for you to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information.

The aim of this experiment is to understand the physiological changes related to touching, feeling or hearing certain fabrics. Biosensors such as GSR are expected to pick up the touch-related physiological activity, which can then be correlated to the fabric that was being touched.

Procedures of Experiment
• You will be asked to read, understand and sign a consent form. Note that you can withdraw at any time without giving any reasons.
• You will be asked to switch off your mobile phone before starting the trial.
• You will be shown how to feel or touch the fabrics provided and how to use the website or iPad app.
• You will be assisted with putting on the biosensors such as the GSR sensor.
• During the experiment skin conductance and temperature will be recorded.
• After each fabric a baseline recording of your responses will be recorded in a relaxed position.
• Only your verbal data will be recorded by audio recording during the post-experiment interview.
• Extracts of interviews may be included in reports, but you will not be identifiable from the data.
• Photographs of clothing will be taken, but you will not be photographed.

The time limit is 2.5 hours per participant for this experiment and participants will be paid according to the university norms for their participation. It is up to you to decide whether or not to take part. If you choose not to participate it will involve no penalty or loss of benefits to which you are otherwise entitled. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. All data will be collected and stored in accordance with the Data Protection Act 1998.

Procedures for Physiological Recordings:
The sensors to be used for this study are to record the skin conductance. All of these sensors are non invasive. The two recordings are done using galvanic skin response (GSR, temperature) placed on the wrist.

All data will be collected and stored in accordance with the Data Protection Act 1998.
Informed Consent Form for Participants in Research Studies

(This form is to be completed independently by the participant after reading the Information Sheet and/or having listened to an explanation about the research.)

Title of Project: Digital Sensoria
This study has been approved by the UCL Research Ethics Committee: MSc/1011/006

Participant’s Statement

I ……………………………………………………………………………agree that I have

- Read the information sheet and/or the project has been explained to me orally;
- Had the opportunity to ask questions and discuss the study;
- Received satisfactory answers to all my questions or have been advised of an individual to contact for answers to pertinent questions about the research and my rights as a participant and whom to contact in the event of a research-related injury.
- Given consent that the interview is audio recorded.
- Given consent that my GSR and temperature are recorded

I understand that I am free to withdraw from the study without penalty if I so wish and I consent to the processing of my personal information for the purposes of this study only and that it will not be used for any other purpose. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: Date:

Investigator’s Statement

I …………………………………………………………………………………confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: Date:
Figure 9. Experiment brief which was read aloud to each participant

Have you read the information sheet and filled in the consent form and the questionnaire?

Is the wrist biosensor fitted and still comfortable for you? The biosensor is still collecting your GSR, (or sweat response) and body temperature, which we will use to assess your emotional states during the experiment.

During this part of the experiment you will be asked to feel fabric for 1 minute and think about how it feels to touch and how it makes you feel. When I say start, please click the wrist band and start feeling the fabric. When I say stop please click the wrist band again.

Then I will ask you to use a website to enter information about your fabrics. The website will display a simple visualisation of your physiological data from when you were feeling the fabric.

We walk through using a test fabric first to familiarise yourself with the fabric feel time and to test using the website.

Please complete all the information requested on the website and enter your participant number in the 'Note' field.

I will take photos of your clothing and store the images on the desktop of the computer for you to upload on the website.

Then I will ask you to add information for both your items of clothing.

After this, I will ask you some questions in an interview which will be audio recorded.

Any questions?

Test fabric feel time 1 minute. Think about about it feels to touch, think about words to describe how it feels, is it a pleasant feel, or unpleasant, how does it make you feel to be touching the fabric?

Enter test fabric onto website. Images are on the desktop when needed.

- This is the visualisation of your physiological data from when you were touching this test fabric.
- Choose any emotion, the closest to how you feel about the fabric.
- Hand feel, again choose the closest match to how it felt to touch.
- Scan through the images and choose the one which best represents the fabric.
- Upload the two images you wish to share about this fabric
- Check the care label to see the fibre composition
- Please enter your participant number which is___
Figure 10. Participant checklist used during experiment to ensure consistency.
Figure 11. Experiment semi-structured interview questions

Are you interested in fashion and clothing?
How did you feel about being asked for this information?
Which bit of information do you think best represented your fabrics?
Which bit of information do you think didn't represent the fabric?
Which information did you find most interesting?
Which did you find least interesting?
How much of the data are you comfortable with sharing online?

What did you think about the representation of your physiological data?
What did you understand it to mean?
Would you prefer to see the information in another form?
How do you feel about sharing this online?
How would you feel about having biosensors constantly collecting and uploading your data?
Do you think seeing a representation of your physiology could help you in any situations?

Would you like to see other people sharing information about their fabrics?
Which information from others would you like to see?
In what form?
How about someone else's physiological visualisation?

Can you think of ways in which you could you use the information we collected from you?
In what ways would you use information collected from other people?
Figure 11. Experiment semi-structured interview questions cont.

When would you use a site like this? (out shopping, getting ready for a party or job interview)

How would you access a site like this? (phone, computer, in a shop)

Can you think of an occasion when this sort of website or the information collected by the website would have been interesting for you?

Do you communicate with other people about your clothes or fabrics?

I’d like to go back to the website now to show you the sorts some of the clothing other people have added. So have a browse, click wherever you want and talk me through your thought processes. Feel free to have a look at whatever you like.

Is this interesting/useful?

Would you like different information?

Is anything missing that you would like to see?

Would you take photos of the clothing differently if you were at home?
<table>
<thead>
<tr>
<th>Reference number</th>
<th>Participant</th>
<th>Theme</th>
<th>Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P6</td>
<td>Language of feel</td>
<td>“If you just got something new you would talk about it on Facebook”</td>
</tr>
<tr>
<td>2</td>
<td>P15</td>
<td>Language of feel</td>
<td>[Referring to a texture image that another participant had selected]: “The lady with the cardboard, its just society gone mad”</td>
</tr>
<tr>
<td>2</td>
<td>P14</td>
<td>Language of feel</td>
<td>“I agree with the person that selected this image for the t-shirt, it did feel a bit clammy and sticky.”</td>
</tr>
<tr>
<td>3</td>
<td>P19</td>
<td>Language of feel</td>
<td>“You see there is a connection that’s happening in somebody’s mind that’s necessarily like, This is what colour it is’, but I think it is a much deeper connection than that. I think its almost more helpful the pictures that don’t directly map on to anything and you have this sense of personal associations that come through.”</td>
</tr>
<tr>
<td>4</td>
<td>P19</td>
<td>Language of feel</td>
<td>[Referring to her own physiological visualisation]: “I don’t know that it mapped directly on to how I was feeling... What an interesting little thing, but I wasn’t engaged with it very much. If I was supposed to engage with it, maybe something a bit more scientific-y.”</td>
</tr>
<tr>
<td>5</td>
<td>P2</td>
<td>Language of feel</td>
<td>“I couldn’t really understand it, but I would like to, so I was curious about it”</td>
</tr>
<tr>
<td>5</td>
<td>P18</td>
<td>Language of feel</td>
<td>“Don’t ask me what that means, I don’t know, but it seems interesting”</td>
</tr>
<tr>
<td>6</td>
<td>P2</td>
<td>Use of physiological data</td>
<td>“Sometimes we don’t know in ourselves what we are feeling, so maybe [comparing to physiological data] would be interesting”</td>
</tr>
<tr>
<td>6</td>
<td>P7</td>
<td>Use of physiological data</td>
<td>“Measuring your reactions with the biosensor is helpful because it is an impartial way of measuring things”</td>
</tr>
<tr>
<td>6</td>
<td>P9</td>
<td>Use of physiological data</td>
<td>“Am I reacting differently, without me knowing?”</td>
</tr>
<tr>
<td>6</td>
<td>P11</td>
<td>Use of physiological data</td>
<td>“There would be responses you would be aware of and that you were not aware of”</td>
</tr>
<tr>
<td>6</td>
<td>P10</td>
<td>Use of physiological data</td>
<td>“Whether my perception of how I feel correlates with what my body is telling me”</td>
</tr>
<tr>
<td>7</td>
<td>P10</td>
<td>Use of physiological data</td>
<td>“If there were baseline values then I would compare to see how their perception of themselves varied with their physiological data and how mine varied”</td>
</tr>
<tr>
<td>7</td>
<td>P1</td>
<td>Use of physiological data</td>
<td>“I would like to see if [other peoples’ data] relates to mine maybe. Compare... if they had the same emotional response that I did”</td>
</tr>
<tr>
<td>8</td>
<td>P7</td>
<td>Use of physiological data</td>
<td>“If you don’t realise that you’re getting stressed, it sort of alerts you to that, then you can maybe try and calm down, but I don’t know how.”</td>
</tr>
<tr>
<td>8</td>
<td>P20</td>
<td>Use of physiological data</td>
<td>“There are some times when I am lost, I really don’t know what I am feeling. So if that gives an idea, maybe I can work on it”</td>
</tr>
<tr>
<td>8</td>
<td>P3</td>
<td>Use of physiological data</td>
<td>“I could see it as a soft mechanism to calm people without having to be all crazy about it”</td>
</tr>
<tr>
<td>8</td>
<td>P19</td>
<td>Use of physiological data</td>
<td>“If I knew this was a sign of me getting too emotional, or too heated up, or too down, this would be very helpful because you can actually know your emotions. When you have to think, I’m getting a little bit angry here, I need to calm down. This would be a sign, an indication.”</td>
</tr>
<tr>
<td>9</td>
<td>P5</td>
<td>Decision making</td>
<td>“I went to the fabric shop to see what they have. Obviously you can’t remember everything, you just remember the ones where you go, Oh I really liked that! But if I had this website or this application on my phone, and I could [upload details of fabrics the site], then I think I would get more out of one single trip rather than having to go back and forth.”</td>
</tr>
<tr>
<td>9</td>
<td>P11</td>
<td>Decision making</td>
<td>“Shopping for a suit for a wedding, some purchase that is for a special occasion, I probably would want to see this sort of information”</td>
</tr>
<tr>
<td>10</td>
<td>P13</td>
<td>Ethics</td>
<td>“Obviously its confidential information, so I wouldn’t want everyone to have access to it. If I wanted to disclose it myself for any reason, then I would be ok with it. For it to be out there and open, I wouldn’t feel happy with that”</td>
</tr>
<tr>
<td>11</td>
<td>P20</td>
<td>Ethics</td>
<td>“It’s about the same weight as my watch”</td>
</tr>
<tr>
<td>11</td>
<td>P20</td>
<td>Ethics</td>
<td>“I’ve got it on now. Its not uncomfortable, its perfectly, kind of wearable. It wouldn’t interfere with my daily routine at all”</td>
</tr>
</tbody>
</table>
## Figure 13. Spreadsheet detailing key points from experiment interviews

| Participant | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | Totals | Mean | Stdev |
|-------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|-----|------|------|
| Gender      | m | f | f | f | m | m | f | m | f | f | m | f | m | f | m | f | f | f | f |    | 9    | 13   |
| Consumer    | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13   |
| Interested in clothing | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 13   |
| Interested in seeing own physiological data | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 19  |
| Prefer to see in graph form | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8    |
| Wants to compare own data over time | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 14   |
| Wants to compare data with other's | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 14   |
| OK to share physiological data globally | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6    |
| OK to share physiological data with caveats | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12   |
| Mentioned physicality of sensor | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 6    |
| Health in relation to biosensor | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5    |
Figure 14. Summary of calculations reported in Results 2 chapter to analyse aggregate trends. The SQL code is simplified, not showing surrounding data structures or formatting.

<table>
<thead>
<tr>
<th>Measure</th>
<th>SQL code</th>
<th>Pseudocode</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collective emotions</td>
<td>(emotion_frequency / total_frequency * 100), emotion GROUP BY emotion</td>
<td>Each emotion as a percentage of the total wardrobe</td>
<td>Two participants selected the emotion 'angry': (2/40*100) = 5%</td>
</tr>
<tr>
<td>Collective texture words</td>
<td>(texture_word_frequency / total_frequency * 100), texture_word GROUP BY texture_word</td>
<td>Each texture word as a percentage of the total wardrobe</td>
<td>One participant selected the texture word 'limp': (1/40*100) = 2%</td>
</tr>
<tr>
<td>Collective fibre content</td>
<td>sum_fibre_percentages / total_frequency, fibre GROUP BY fibre</td>
<td>Each fibre as a percentage of the total wardrobe. Fibre contents are stored as percentages of each textile</td>
<td>There are 3 textiles containing viscose in the wardrobe, totalling 230%. 230% / 40 = 6%</td>
</tr>
<tr>
<td>Texture image / emotion matrix</td>
<td>COUNT(), texture_image, emotion GROUP BY texture_image, emotion</td>
<td>Frequency of combinations of texture image category with emotion as selected by a single user</td>
<td>One participant selected a texture image within the 'cool' category along with the emotion 'angry'</td>
</tr>
<tr>
<td>Texture word / emotion matrix</td>
<td>COUNT(), texture_word, emotion GROUP BY texture_word, emotion</td>
<td>Frequency of combinations of texture image category with emotion as selected by a single user</td>
<td>One participant selected the texture word 'clingy' along with the emotion 'interested'</td>
</tr>
<tr>
<td>Texture word / texture image matrix</td>
<td>COUNT(), texture_word, texture_image GROUP BY texture_word, texture_image</td>
<td>Frequency of combinations of texture word with texture image category as selected by a single user</td>
<td>One participant selected the texture word 'cool' along with an image from the texture image category 'cool'</td>
</tr>
<tr>
<td>Fibre / emotion aggregate</td>
<td>fibre, sum_fibre_percentages / total_frequency, emotion GROUP BY fibre, emotion</td>
<td>Each fibre / emotion pair as a percentage of the total wardrobe</td>
<td>23% of emotions selected for cotton fibres were 'interested'</td>
</tr>
<tr>
<td>Fibre / texture word aggregate</td>
<td>fibre, sum_fibre_percentages / total_frequency, texture_word GROUP BY fibre, texture_word</td>
<td>Each fibre / texture word pair as a percentage of the total wardrobe</td>
<td>34% of texture images selected for polyester were within the category 'thick'</td>
</tr>
<tr>
<td>Fibre / texture image aggregate</td>
<td>fibre, sum_fibre_percentages / total_frequency, texture_image GROUP BY fibre, texture_image</td>
<td>Each fibre / texture image category pair as a percentage of the total wardrobe</td>
<td>43% of texture words selected for viscose were 'organic'</td>
</tr>
</tbody>
</table>